ELECTRICAL ENGINEERING

Registered United States Patent Office

The Cover: Convair XF2Y-1 *Sea Dart*, the world's fastest seaplane, exceeded the speed of sound in a shallow dive from an altitude of 34,000 feet during a routine test flight off the coast of San Diego, Calif. At rest in the water, the 52-foot seaplane floats with its 34-foot delta-wing only an inch or two above the surface, but it climbs quickly onto its hydro-twin skis a moment after the start of a take-off run. (Also see p. 931.)

OCTOBER
1955

The Year Ahead ..... M. D. Hooven 863
Training Programs of Industry for Graduate Engineers ..... M. J. Kelly 866
The Mechanical Engineering of Dielectrics ..... Bryce Maxwell 870
Explosion-Proofing Instrumentation Equipment for Flight-Test Use ..... B. F. Hager 873
Recent and Past Progress in Power Transmission ..... Philip Sporn 878
The Struggle for Unity ..... W. B. Morton 885
The Shippingport Atomic Power Plant ..... P. A. Fleger 892
Standard Functional Divisions for Electronic Equipment ..... R. S. Shultz, W. R. Waltz 896
Integrating Amplifiers Broaden Field for Application of Electric Drives ..... C. D. Beck 901
High-Temperature Area-Type Titanium-Dioxide Rectifiers ..... H. C. Gorton, T. S. Shilliday, F. K. Eggleston 904
Influence of ID-OD Ratio on Magnetic Properties of Toroidal Cores ..... R. W. Roberts, R. I. Van Nice 910
The Philosophy of Codes of Ethics ..... L. L. Fuller 916
New Circuits for Recurrent Surge Oscillography ..... D. D. Davis 919
How to Compute the Thawing of Line Ice ..... C. H. Spaderna 923
Electric Transducers for Automatic Weighing ..... R. E. Bell 926

TECHNICAL PAPER DIGESTS

Charts for Calculating Locomotive Performance ..... R. D. Charlton 884
Power-Class Recloser for High-Speed Circuit Clearing ..... E. J. Field, D. L. Leatherberry 895
A Tapered Strip Line for Pulse Transformer Service ..... F. G. Primozich, E. R. Schatz, J. B. Woodford 908
Propagation Mechanism of Discharge on Oil Surfaces ..... J. G. Anderson, T. W. Liao 909
Transient Response of Sampled-Data Systems ..... E. I. Jury 915
Tests on 138-Kv High-Speed Oil Circuit Breaker ..... Otto Naef, R. D. Hambrick 925

MISCELLANEOUS SHORT ITEMS: Facilities for Atomic Power Nearing Completion, 865; Constant Lighting for Camera, 877; Largest Conductor-Cooled Generator Nears Completion, 900; Rectifier Locomotive Tested, 907; Furnace Transformers Built for Steel Mill, 914; Outdoor Compressor for High-Speed Motor, 918; Miniature Mercury Battery, 928

Institute Activities 929
AIEE Personalities, 946; Obituary, 947; Membership, 947

Of Current Interest 948

Industrial Notes 18A
New Products, 26A; Trade Literature, 54A

Index to Advertisers 76A

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Three conductors for one of the two 115kv Oilostatic circuits are pulled in.

Section of Oilostatic circuit showing paper-insulated cables, oil, steel pipe and corrosion protective covering.

another utility selects

OILOSTATIC

for economical high voltage transmission

In Sacramento, California, Oilostatic Transmission Systems for two 8,800 foot 115kv circuits were buried directly under the city streets. Simplicity of installation, economy, and service-proved reliability dictated the choice of this type of installation to carry 70 MVA per circuit.

Oilostatic Systems consist of paper-insulated cables in a welded steel pipe filled with oil under 200 psi pressure. This system provides maximum dielectric strength, stability, and current-carrying capacity. Automatic pressure controls and indicating instruments reduce the necessity for inspection to an absolute minimum.

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Available with either copper or aluminum conductors

OKONITE SINCE 1878 ***insulated cables***

2629

HIGHLIGHTS.....

The Year Ahead. President Hooven, in his first presidential address, predicts a bright future for the profession of electrical engineering. The aims for AIEE for the coming year will be to extend the services of the organization, and to encourage unity within the profession whenever possible (*pp. 863–5*).

Recent and Past Progress in Power Transmission. The advancements in electric power transmission from 1900 to 1945 are given. Ten problems that had to be mastered to bring transmission to the mature stage are discussed (*pp. 878–83*).

Influence of ID-OD Ratio on Magnetic Properties of Toroidal Cores. Results are given of a theoretical calculation of the dependence of the *B-H* relation on id-od ratio of toroidal cores, as well as the elaborate experiments to obtain reliable data to prove or disprove the results. The need for such investigations was realized when designs were being made for magnetic amplifiers (*pp. 910–4*).

Mechanical Engineering of Dielectrics. The design of dielectric components for electronic applications cannot be done by usual design methods if it is to do a mechanical job as required. A new approach to the problem is presented, which takes various properties into consideration (*pp. 870–3*).

High-Temperature Area-Type Titanium-Dioxide Rectifiers. Recently significant advances have been made in the maximum temperature of operation and in the forward-to-reverse resistance ratio of titanium-dioxide rectifiers. For the past several years, the Battelle Memorial Institute has been directing research work towards their development, as described in this article (*pp. 904–7*).

News Index

Institute Activities **929**

AIEE Pacific General Meeting 929
Aircraft Electrical Applications Conference 931
Future AIEE Meetings 932
AIEE Board of Directors Report 933
Insulation Classification Changes 934
New Air Secretary Quarles Is Past President of AIEE 935
Motor Application to Space Heating, Cooling Equipment Meeting 936
Eastern Joint Computer Conference 937
Committee Activities 938
AIEE Personalities 946
Obituaries 947
Membership 947

Of Current Interest **948**

New G-E Building Dedicated 948
Otis Engineers Demonstrate Trav-O-lator and Elevoice 949
International Conference of Peaceful Uses of Atomic Energy 950
Future Meetings of Other Societies 952

The Struggle for Unity. Various organizations in the past have made accomplishments advancing the status of the engineer, but there has been no group that could claim to represent the entire profession. A new plan for unity called the "American Engineering Association" is presented for consideration (*pp. 885–91*).

Announcement

On the last page of this issue you will find post cards to help you contact advertisers in whose products or services you are interested.

Please use these cards when you desire more information about products advertised in this issue of Electrical Engineering...

Electric Transducers for Automatic Weighing. A presentation of the advantages and disadvantages of various types of transducers, as linear differential transformers, synchros, potentiometers, cut-off devices, and strain gauges, which were designed for use with mechanical scales for automatic weighing control (*pp. 926–8*).

Training Programs of Industry for Graduate Engineers. The graduate engineer is inadequately prepared for the professional career in the field of creative technology. This article describes industry's training of graduate engineers in this area (*pp. 866–9*).

Explosion-Proofing Instrumentation Equipment for Flight-Test Use. There has been constant improvement in aircraft equipment to make it explosion proof but there still are some hazardous electrical equipment items in flight-test instrumentation use. This article describes modifications recently made to equipment components so as to change them from hazardous items to explosion-proof items (*pp. 873–7*).

Standard Functional Divisions for Electronic Equipment. Improvements in military electronic-equipment reliability, as well as new concepts in equipment design and procurement, can be made if electronic subassemblies are standardized and their functional requirements described and recommended. This article describes the first stage of a long-range program to increase reliability through use of electronic subassemblies as building blocks (*pp. 896–900*).

Bimonthly Publications

The bimonthly publications, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

The Philosophy of Codes of Ethics. The construction of a code of ethics for the engineering profession should start with the analysis of the function it performs in society, so that we will know how the role should be played and what restraints must be observed to make it most effective (*pp. 916–8*).

How to Compute the Thawing of Line Ice. Various experiments have been made and formulas derived, so as to analyze the heat losses that may help to understand and control the thawing processes (*pp. 923–4*).

New Circuits for Recurrent Surge Oscillography. A new transient analyzer, which is a combination versatile low-voltage repetitive impulse generator and cathode-ray oscillography, is described. It has many advantages for increasing the accuracy in producing and analyzing transient response measurements (*pp. 919–23*).

Integrating Amplifiers Broaden Field for Application of Electronic Drives. A description of the design and uses of a new integrating amplifier in speed-regulator applications is given (*pp. 901–4*).

The Shippingport Atomic Power Plant. About 13 months ago, ground was broken dramatically for the Duquesne power plant which will produce electricity by means of a nuclear reactor (*pp. 892–4*).

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

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FLORIDA POWER & LIGHT SELECTS S&C POWER

Florida Power & Light Company is the Sunshine State's fastest growing utility. Year after year more manufacturers, more businesses, and more commercial enterprises are moving into the territory it serves. Rapid population gains have increased customers by 138%, and more than tripled demands on the Florida Power & Light system since the end of World War II.

To satisfy these demands, Florida Power & Light has carried on an extensive power expansion program which, by the end of 1955, will have required the investment of $250,000,000 since V-J Day.

For an expansion program of such importance, it is only natural that the greatest possible care is used to make sure that service continuity is maintained and system equipment is protected.

Aerial view of the Hialeah section of Miami—one of the areas where rapid building of homes and industry has increased demand for light and power to six times what it was ten years ago. Hialeah Park is nationally famous . . . open the year around . . . host to hundreds of thousands annually.

THE YEAR AHEAD

M. D. HOOVEN
PRESIDENT AIEE

In this his initial presidential address, President Hooven tells of our responsibilities to the other branches of the engineering profession—the recently conducted opinion survey—the work of the consultants on AIEE management—and his ideas on how the profession should advance.

THE ART of electrical engineering is expanding explosively. No man dares to say what accomplishments will be made in the year just ahead of us. Electricity, which is for us both a high priestess and a handmaiden, counts upon her votaries to lead the engineering profession in its reconstruction of this already very pleasant world of ours. Undreamed of advancements will undoubtedly be made. More brilliant young people will come into the engineering profession. Greater numbers of older and wiser engineers will assume heavier responsibilities in the development of our present-day technological culture.

Already there are some 700,000 professionals who may be listed under the general classification of engineers and physical scientists. This figure even now dwarfs the number of those engaged in the other traditional professions. The ministry, medicine, and law account for only 200,000 each, the engineers and scientists outnumbering the other three combined. The demand for engineers is said to be 30 to 40-thousand new graduates annually. This annual demand is three times the requirements of the other three professions put together. Is it not reasonable to say that the intellectual leadership of the next generation must come from the ranks of the engineers? Sheer numbers require it. Beyond numbers is the fact that college-qualification test scores used for student deferment indicated those most qualified intellectually are taking the science and engineering courses.

Because of the very nature of the segment of the profession labeled electrical, and because of the across-the-board characteristic of the electrical engineer which requires him to help the other branches of the profession to communicate and calculate, to control and coordinate, and to move and measure those items with which they are concerned, the electrical engineer must be a kind of integrator among the other members of his profession. There are on this continent probably over 100,000 electrical engineers, 60,000 of whom we know graduated in electrical engineering from accredited colleges in the last dozen years. The AIEE is the largest engineering body in the world, having close to 50,000 members. However, only half of the electrical graduates appear to join AIEE. While it is hoped that some of the remainder join the Institute of Radio Engineers, our much-to-be-admired specialized society within the field of electrical engineering, we must make sure that in the next year and during the years to come, all electrical graduates will be absorbed into the organized profession. Here is one of the obvious jobs of this year's administration.

UNITY OF EFFORT

WE MUST ALSO RECOGNIZE our responsibilities to the other branches of the engineering profession. Traditionally the AIEE membership has always favored unity with its sister societies. In spite of the fact that AIEE was one of the first four fractionations of the engineering profession, the historical aim of all of its administrations appears always to have been unity of effort with the other societies, if not always unity of organization. This is as it should be. There now exist two unity bodies which AIEE is supporting fully. Engineers' Council for Professional Development (ECPD) which, in addition to the founder societies and the chemical engineers, includes the American Society for Engineering Education, the Engineering Institute of Canada, and the National Council of State Boards of Engineering Examiners, which is the older of the two bodies and concerns itself with intraprofessional activi-

Text of the presidential address presented at the AIEE Pacific General Meeting, Butte, Mont., August 15–17, 1955.

M. D. Hooven is electrical engineer, Public Service and Gas Company, Newark, N. J.

ties such as education—high school, college, and post-baccalaureate—, accreditation, student development, ethics, and vocational guidance. This Council, a strong performer for the 20 years of its life, needs no especial aid. It is functioning in excellent fashion with the electrical engineers, carrying at least the share of the burden that belongs to them. Among many other activities, ECPD plans during the coming year to sponsor a thorough analysis of the responsibilities of the engineer in this present-day culture and his education toward these responsibilities. No extraordinary amount of effort needs to be directed toward ECPD by AIEE at this time.

Engineers Joint Council (EJC), handling extra-professional activities and being the newer of the two unity organizations, needs perhaps more help. This organization, which held its first General Assembly last year, is still in the process of being reviewed and revised. A planning committee is now being formed whose duty will be, so far as possible, to chart the future of the organization of the profession. Belonging to EJC in addition to the founder societies, the American Institute of Chemical Engineers and the American Society for Engineering Education, are the Society of Naval Architects and Marine Engineers, the American Water Works Association, and the American Society of Refrigerating Engineers. Two societies in which many electrical engineers are particularly interested (actually, over one-fourth of the Institute membership belongs to one or the other) are the National Society of Professional Engineers and the Institute of Radio Engineers, neither of which takes part in either of the unity councils, and both of which AIEE would be glad to see as a part of the unity movement. This administration's aim for the coming year will be to encourage, whenever possible, unity of organization within the profession. It goes without saying that AIEE will continue with its sister societies in its well recognized aim of unity of effort on all fronts.

THE OPINION SURVEY

THIS ADMINISTRATION will continue to boast of the tradition of democratic government of the Institute and to maintain that tradition. At a recent meeting of the Board of Directors a rather complete opinion survey was presented which most certainly will become a guide to practice during the coming year. The opinion survey was made by means of personal interviews with a scientifically selected sample of AIEE membership by the Opinion Research Corporation of Princeton, New Jersey. I hope it will be possible that the detailed findings of the survey, including answers to more than 100 questions, will be spread before the entire membership of the Institute for thoughtful study. I would be remiss in my duties as President if I did not present briefly the advance information from this survey that has come to my knowledge. Many things we knew beforehand; reassurance of one's prior convictions, however, is always comforting. For instance, most of us in my generation were quite sure that this Institute was primarily interested in the progress of the art and in the development of technical and engineering knowledge. In the survey, 49 per cent of the membership chose advancement of knowledge over improvement of status as the objective to which the Institute should pay most attention. Those who thought the more important of the two objectives was the improvement of status and prestige accounted for only 26 per cent; the remainder said that the two objectives should receive equal attention. This result is particularly impressive when it is considered that two-thirds of the membership are under 45 years of age. It is, however, exactly in line with the concepts of the founders of the Institute who seemed to feel that "status and prestige" were by-products of knowledge, skill, and service and not something to be created separately by pressure of members and publicity.

Since more than one-half of us think that the publications of the Institute are of greatest value of all that the Institute has to offer, there have been many suggestions concerning possible improvements in publication policy, even though two-thirds of us said that we should change nothing. Surprising is the fact that both Electrical Engineering and the Bimonthlies are equally popular. It is sufficient to say at this moment that the Publication Committee and its associates are continually engaging in studies and analyses whose aim is to provide better service to the membership.

Another good way to learn about the operation of the Institute is simply to read thoughtfully the Annual Report of the Board of Directors, published in full in the August issue of Electrical Engineering. There one may interpret his own figures and come to his own conclusions. Read, for instance, the simple list of numbers of members at the end of each year. It was 17,000 in 1925, 15 years later 17,000, and almost three times that amount at the end of the next 15 years. Read about rising costs and the great increase in the number of sessions and papers. The three-headed Cerberus of tremendous growth, quick inflation, and rapid development of the art can plainly be seen to have been nipping at the heels of recent administrations. Parenthetically, let me point out that my metaphors are not mixed too badly. Cerberus was the three-headed dog who guarded the gates to Hades and thus made difficult the path of pilgrims to the regions beyond. While the difficulties which beset AIEE administrations may very well be accelerators rather than retarders along the path of the pilgrims, I sometimes wish that these three heads, or rather three headaches, could have come along at different times.

CONSULTANTS ON AIEE MANAGEMENT

TO HELP in handling administrative problems, the Institute has employed the services of outside consultants. Public Relations has been thus handled in excellent fashion for several years. This year new consultants have been retained on management practices. Since this survey is just about to get underway, the results of the study will not be forthcoming for several months. In the meantime, however, it is interesting to speculate on what might be done with some of the practices that have arisen because they grew that way.

For instance, is the present method of districting correct? Many committees have investigated this over the past decades. The new objective judgment of a consultant might be valuable in this problem.

Should the field work of the Institute be handled from Headquarters or from regional offices? I am sure that at this moment the answer is unknown in terms of present-day efficiency studies; a consultant's point of view on this question would be invaluable. In this connection, is New York the right place for Headquarters? Should it be Philadelphia, Chicago, or Pittsburgh; should it be Butte, Montana? Let's get an objective answer to these questions.

Do we run our meetings correctly, and will they meet the present-day competition of television or of adult education programs? Who knows? Again there is room for outside opinion.

There are large areas, however, where no consultants are needed. The strength of AIEE lies in its technical work and in its local activities. Of these two things the Institute is most proud. Here is where we serve best.

TECHNICAL ACTIVITIES INCREASING

THE TECHNICAL ACTIVITIES of the Institute have grown with tremendous rapidity since the end of the war and the implementation of the 1946 Asheville Resolution. Three new technical committees have just been approved by the Board of Directors, making a total of 42; they range in subject matter from telegraph systems, said to have been the subject mainly responsible for the formation of the Institute, to nucleonics, one of the more recent subjects demanding attention. As of today there are 109 sections; under consideration are new sections as far apart as Paducah, Kentucky, and Caracas, Venezuela.

The final stronghold of the Institute lies, however, in the individuals who belong to it and in the recognition from those individuals of the part that each one must play in his professional life. Vannever Bush has said "the essence of any profession is its ministry to its public." This is particularly true of the engineering profession in this day and age. It is perhaps more true of the electrical engineer than of those from other branches of the profession. In this electrical age, every engineer has the peculiar privilege of working for many masters. The Leonardo Da Vincis of the past worked under the patronage of princes and potentates; the professionals of the last century worked for individual clients and for the just-being-formed corporations. In this day and age the clients of electrical engineers are connected in multiple, as it were. Each of us works for many clients, usually for an association of individuals loosely termed a company or corporation, or for the government, or, in more general terms, for the community in which we live. The duties of the electrical engineer may range from fixing his neighbor's toaster through doing a chore for the Civils or Mechanicals, through serving with his community's school boards, church committees, and political groups, to his bread-and-butter job which may vary from research to sales.

With each member of the electrical profession constantly growing more aware of the progress of his own art and of the part which that art's progress plays in his community development, the coming year should be one of continued advancement. Your administration plans to put itself in the position of sponsoring, guiding, and forwarding this continued progress of the profession in "The Year Ahead."

Facilities for Atomic Power Nearing Completion

Ohio Valley Electric Corporation (OVEC) has passed the half-way point in bringing into service facilities to supply the electric power requirements of the Atomic Energy Commission's Portsmouth (Ohio) Project.

The half-way mark was passed when the sixth of 11 giant steam-electric generating units being built by OVEC was completed and placed in operation during the week ending September 2, 1955. From the standpoint of over-all work completed, and equipment erected, the job is about 85 per cent completed. The first two OVEC units went into service on February 15 of this year; the completion of the sixth unit brought OVEC capability up to 1,290,000 kw.

The latest unit to go into service is the third unit at Kyger Creek Plant, on the Ohio River near Gallipolis, Ohio. Unit *3* at its sister station, Clifty Creek Plant, also on the Ohio River at Madison, Ind., was placed in operation in July.

The two stations, upon their completion early in 1956, are said to be the largest power plants built by private enterprise. Larger of the two, Clifty Creek, will have six units with a total generating capability of 1,290,000 kw. Kyger Creek will have five units and a total capacity of 1,075,000 kw. Each of the 11 units has a capability of 215,000 kw.

Ground was broken at both plant sites in December 1952, signaling the start of a schedule which called for the simultaneous construction of the two power plants, 180 miles apart, and the completion of their 11th and final unit in slightly less than $3^1/_2$ years.

The latest unit, Kyger Creek's Unit *3*, was originally slated to be in operation about September 15. The five subsequent units of the two plants are expected to be completed even further ahead of schedule. Four of the remaining units are expected to be in operation by the end of 1955, and the last unit is scheduled for early 1956.

Construction of the 330,000-volt transmission system, which links Kyger and Clifty Creek Plants with the Portsmouth Area Project, also has been completed ahead of schedule. The last of seven double-circuit 330,000-volt transmission lines went into operation June 16.

OVEC's transmission network, which at 330,000 volts, consists of 388 miles of double-circuit lines, many of which were extended through rough terrain necessitating new methods of construction, system is interconnected with transmission systems of 15 OVEC sponsoring companies.

Training Programs of Industry for Graduate Engineers

M. J. KELLY

Today's problems facing research laboratories in building a competent staff for creative technology, as well as the problems of the technical schools in establishing curricula suited to today's changing needs, are summarized. Experience of one large industrial laboratory in an educational program has led to the conclusions presented on training requirements.

INDUSTRY'S TRAINING PROGRAMS for graduate engineers and the need for them is too broad and complex a topic for comprehensive treatment in a short period of time. Therefore, this discussion is restricted to industry's training of graduate engineers in the area of creative technology. This is uniquely the area where the graduate engineer is inadequately prepared for the professional career on which he embarks. The problems and programs of the communications and electronic industry will be taken for a case study. Its problems have large areas in common with those of the power, mechanical, aeronautical, and chemical industries.

The term "creative technology" is used to encompass the operations of applied research, development, and systems and design engineering. It is this sequence of operations that extends the knowledge that scientific research provides of nature's laws and materials, and utilizes it in creating new facilities for use in our society—in both the civilian and military areas. "Research and Development," as commonly used, encompasses those operations which are included in "creative technology" and basic or pure research as well.

There is a growing body of statistical information about the nation's Research and Development; that of the National Science Foundation is most comprehensive and authoritative. From these statistics, it is seen that in the last 15 years there has been a tenfold increase in the nation's effort in creative technology. In 1939, its annual dollar volume (measured in today's dollars) was some $400 million; today, its annual volume is some $4 billion. In carrying out the programs financed by these expenditures, some 20,000 graduate engineers and scientists were employed in 1939; today, the number is perhaps 150,000 to 175,000. In this 15-year period, the volume of effort in creative technology is greater than for the previous 165 years of the nation's life. The threats to our nation's security initiated this rapid expansion. In 1940, when the nation became concerned with building military strength, it turned to the application of science for creating new weapons systems and the strategies for their use. Under the leadership of the Office of Scientific Research and Development headed by Vannevar Bush, a huge national effort was organized and staffed by scientists and engineers from the universities and the research laboratories of industry. Their efforts revolutionized warfare and established for the nation, through the evidence of their productivity, a much higher level of expenditures in applied science and technology for both the military and the civilian economy.

About 60 per cent of the effort of the 15 years has been for military application and financed by the government, and the remainder for the civilian economy and financed by it. At present, the effort is almost equally divided between the creation of facilities for the military and for the civilian economy. Currently, 75 per cent of the work is done by industry, 15 per cent by government, and 10 per cent by academic and nonprofit institutions.

CHANGING TECHNOLOGY

THE CHARACTER of the technologic operations in bringing new facilities into being has greatly changed, and to an extent somewhat comparable to that of the change in volume of effort. Until early in the present century, new facilities for our society came into being through a creative step made most often by the lone inventor followed by hard-headed ingenious Yankee design for manufacture and use. As industry established its research laboratories, the pattern slowly changed to creation through application of the scientific method by teams of applied scientists of these laboratories, followed by ever more fundamental development and design by teams of graduate engineers. The tempo of this change in pattern was greatly increased by effort in building military strength through application of science. This change in character of work has brought with it changes in the demand placed upon the professional personnel in the program. The amount and character of training required have changed, and the human qualities demanded of the individual have become more exacting.

The expanded basic research in the physical sciences of the period has increased the scope and depth of knowledge of matter and nature's laws governing its behavior. This has provided a vast reservoir of opportunity for creative technology, in providing new weapons for our protection

Full text of an address given before the Seventy-fifth Anniversary Meeting of The American Society of Mechanical Engineers, Stevens Institute of Technology, Hoboken, N. J., April 16, 1955.

M. J. Kelly is president of Bell Telephone Laboratories, New York, N. Y.

and new facilities of great variety for enrichment of our living, and for decreasing man's effort in producing them.

In the course of their creative effort, they are adding new knowledge in technology and engineering at an unprecedentedly high rate. This dynamic progress of technology and engineering is presenting most difficult problems to our engineering educators. In an attempt to solve them, some of our schools of technology are making major changes in their curricula.

COMMUNICATIONS AND ELECTRONIC INDUSTRIES

TO PRESENT THE PROBLEMS of the laboratories of the communications and electronic industries in building a competent staff for creative technology and of schools of technology in establishing curricula suited to the changing needs, the expansion of the technology during these past 15 years of intensive and continuously expanding effort will be reviewed.

In 1940, the upper or high-frequency limit of utilization of the electromagnetic spectrum in communications was some 300 mc. During the ensuing 15 years, the upper limit has been extended to almost 30,000 mc, a hundredfold expansion of usable frequency range. Through the availability of these higher frequencies, many new military and civilian services have become possible. Broad-band repeatered radio transmission is typical. Today, there are transcontinental radio systems, with repeatering or amplification every 30 miles, a transmission bandwidth of 5 mc, and carrier frequencies in the 3,000- to 8,000-mc range. Thousands of telephone conversations may be transmitted simultaneously over these broad-band paths. Television programs cover the nation through the interlinking of radio transmitters by these transmission paths. Radar for military purposes has been made possible through the availability for use of these higher frequencies. In this period, radar has become a mature technology, servicing a tremendous variety of important military applications.

To implement these new microwave services, a completely new technology of electronic devices and transmission components has been necessary. A wide range of new knowledge in materials and circuitry has been required. In the utilization of this new range of the electromagnetic spectrum, more new technology has been established in these 15 years than in the previous 40, when there was a gradual extension in the area of use of the electromagnetic spectrum to a 300-mc upper limit.

Prior to 1950, the thermionic hot-cathode vacuum tube was the active element in substantially all electronic systems. Through research in the physics of the solid state in the early years immediately after the war, multi-element solid-state electronic devices were created that increasingly are capable of performing the many functions of vacuum tubes. These solid-state electronic devices, called "transistors," offer important functional and economic advantage, occasioned in part by their extremely small size, low power consumption, low voltage requirements, and promise of indefinite reliable life. For many services in the military and civilian areas now employing vacuum tubes, the solid-state devices will bring important economies and higher levels of reliability. This will extend the scope of these already established services.

The favorable properties of the solid-state electronic devices are also opening vast new areas for electronic applications. The more sophisticated of the high-speed digital electronic computers, for example, may employ as many as 10,000 active electronic devices. When thermionic vacuum tubes are employed, the size of the installation, the large power consumption, the heat generated, and the reliability difficulties make for high-cost operation and thus limit the scope of application. With solid-state electronic devices, the size, the power consumption, and the heat generated are all reduced manifold, and there is promise of long trouble-free life of components. The high-speed digital computer and associated electronic functional gear provide means for extensive automatic operation in industry and in business. With the economy and reliability of the solid-state devices, it can be reasonably anticipated that increasing areas of routine manual and mental operations of industry and business will be made automatic. We are entering an era of increasing "automation" that may well have social and economic effects upon our society greater than those of the mechanization of the past century.

The introduction of solid matter into active electronic devices has brought into being a completely new area of technology. The materials, physical, chemical, and structural problems of solid-state electronic devices bear little resemblance to those of vacuum-tube electronics. The circuitry of solid-state devices, while related to that of vacuum-tube electronics, is still largely different. New areas of electronic application, such as automation in business and industry, that solid-state devices make possible are necessitating the development of new technologies.

Areas of mature and previously relatively static technology are also being revitalized in this period. A typical example is the telephone cable, including both its sheathing and conductor designs. In the immediately previous decade, there were no major advances in telephone-cable technology. The conductors were, in general, insulated by paper pulp or a wrapping of paper tape; the bundles of conductors were housed in an extruded lead sheath and there was little change in cable structure.

Chemical research in plastics made available a variety of new wire coverings with improved electrical, mechanical, and environmental-resistant properties. Also, specially processed polyethylene may be substituted for lead in the sheathing. With this variety of materials possessing different physical and electrical properties, many new cable-structure designs are now possible.

This new flexibility in design is most timely, for with the lower cost levels for amplification that solid-state devices will provide, cable structures will be radically altered to realize minimum over-all transmission costs.

SYSTEMS ENGINEERING

IN THE DEVELOPMENT of new systems, either in weaponry or for the civilian economy, based upon this expanded technology, a new area of engineering effort in creative technology has evolved. It is frequently called "systems

engineering." Here, through analytical studies and evaluations, a plan for the development of a new system is formulated. For example, in 1945 and 1946, an elaborate study was made leading to an antiaircraft guided-missile development. This study made available the development plan of the NIKE missile. It stated the performance characteristics that could be obtained from existent basic scientific knowledge and technical arts and prescribed the technical characteristics of the system. The NIKE, first produced in 1952, was very much as predicted some five years earlier. Without such systems engineering studies, the programming, organization, and operation of the development of the elaborate electronic weapons, communications, and automation systems of today could scarcely be accomplished; most certainly their development would be more costly, wasteful of technical manpower, and more extended in time.

These are perhaps enough examples of the increasing scope and complexity of communications and electronic technology. They make it evident that the young man of 1955, entering his career in creative technology in electronics and communications, is presented with a vista widely different from that of the young man of 1940. A maturity in the physical sciences of a new order must be integrated with his engineering and technical background.

At the close of World War II, the laboratories of the electronic and communications industries were presented with the grave problem of a large increase in their staffs to meet their postwar obligations. Military research and development was to continue at a level only slightly less than that of the war period. Work for the civilian economy had been largely neglected during the war years, so there was a huge volume of unsatisfied demands there. The new knowledge arising from the military research and development of the war period was available for civilian-use exploitation. To meet these obligations and opportunities, the industries' laboratories had to increase greatly their capacity, which had more than doubled during the war years. The problem of expansion was intensified by the withdrawal from military research and development of a major portion of the university scientists who had volunteered for the war period.

BELL LABORATORIES PROGRAM

In facing its problem, Bell Telephone Laboratories made an appraisal of sources of professional manpower. During the 2 decades preceding the war, the Bell Telephone Laboratories had largely relied upon the graduate schools in science and technology for the men in its research and fundamental development areas. The engineering schools provided the men for specific development, design, and engineering. A small but significant number of the young engineers obtained training to the doctorate level at nearby universities while on the job.

With the greatly increased demands arising from the expansion in work level, as described, the graduate schools of science and technology could not provide men in adequate quantity for our expanded needs in the research and fundamental development areas. A portion of the needs there had to be met by engineering graduates, who at graduation were not prepared for work in this area. Also, the increasing scope and depth of technology placed demands on the recruits for specific development, design, and engineering that exceeded the maturity and training of the graduates of the technical schools.

If we were to expand, as demand required, without dilution of strength, it was necessary for us to provide additional training for our engineering graduates. Some of these additionally trained engineering graduates would supplement the available supply from the graduate schools of science and technology for research and fundamental development areas. Others would fill needs in the specific development, design, and engineering areas. Where subject matter is more engineering in nature, training in the basic sciences beyond the level of the usual 4-year curriculum is essential.

A part-time training on-the-job program was, therefore, initiated. It was to extend over a 3-year period. Approximately half of the time was to be spent in the classroom, with preparation to be done outside regular working hours. The remaining on-the-job time was to be spent at regular work assignments. The men were selected from the upper third, scholastically, of the graduating class of the engineering schools. The starting salary is the normal for engineering graduates, and their compensation progress is not slowed down because of the training program.

The emphasis in the training course is on increasing depth in the physics, chemistry, and mathematics essential to our technology, supplemented by advanced courses in various phases of communications and electronic technology. The usual "orientation" courses for the young men entering an industry are included. Further training in technical writing is found rewarding. The instruction staff is recruited largely from our research and fundamental development staffs, with some aid in recent years from a nearby university. The course material is almost wholly prepared within the Laboratories.

This educational experiment has been considered a success. The professional competence of the incoming 4-year engineering school graduate has been materially increased. Since this is essential for his successful operation in creative technology, the program will be continued. We have learned a great deal about the engineering graduate by the experiment. The initial program was too rigorous for, perhaps, half of them; too rigorous in amount and in depth. Those who prescribed the initial pattern had the background of experience in graduate study in the physical sciences as a guide. Many engineering graduates, even when selected from the upper third, scholastically, are either not sufficiently mature or are lacking in the motivation to pay the price in hard work and very long hours that the man who elects to go into graduate work in science pays if he succeeds. Also, the depth of the training received in the 4-year engineering course was overestimated for some. There was in the early years of the experiment and still is, but to a less extent, a significant spread in depth of basic training of the engineering graduates.

Based on our experience, the course has been gradually modified. It is less ambitious; it starts at a less rigorous

level and its tempo has been slowed. These changes combine in decreasing the depth of training, for its scope has not been altered.

CREATIVE TECHNOLOGY NEEDS

EXPERIENCE in this educational program, accompanied by collateral observations, has led to some general conclusions about educational requirements and the training to meet them for creative technology in electronics and communications. We believe they are largely valid for creative technology in other areas, such as aeronautical, mechanical, power, and chemical. These conclusions may be summarized as follows:

1. Four-year engineering training, independent of the nature of the curriculum, is inadequate for a professional career in creative technology.
2. The larger the basic science (physics, chemistry, mathematics) content of the curriculum, the better is the course for those preparing for creative technology.
3. For the specific development, design, and engineering areas of creative technology, an industry can well provide the 4-year engineer with the additional training required. The more basic the curriculum to which he has been subjected, the better the job an industry can do in its supplementing program.
4. For the research and fundamental development areas of creative technology, training to the doctorate level in science or engineering is most desirable.
5. Training to this level is best done in an academic institution. Industry cannot provide the environment and stimulation of a graduate school.
6. While there is need for more men who are trained to the doctorate level in both science and engineering, the shortage in engineering is much more pronounced.
7. The enticing opportunities for graduate engineers, occasioned by our present relatively low engineering school enrollment and the ever-increasing demands for engineers in our economy, do not provide a good national environment for graduate training in engineering. The pressures on the young engineering graduate to enter industry are terrific. More fellowships with adequate compensation should be made available.
8. The projected increase in college enrollment, almost double by 1970, coupled with the effort to increase the percentage of entrants choosing science and engineering, does not provide a good environment for increasing the basic science content of engineering curricula or for markedly increasing the number of engineers continuing to the doctorate level.
9. In the contest of the free world with Russian-inspired communism, there is no action for increasing the nation's strength of greater continuing importance than that of providing an adequate number of sufficiently trained scientists and engineers to meet the expanding and ever more exacting needs of creative technology.

An increasing fraction of our engineering graduates are making their careers in creative technology; however, the fraction is still somewhat less than half. The others are dispersed through a wide variety of essential areas in our economy. The service industries, such as communications, power, and transportation, and the manufacturing organizations of industry are, perhaps, the largest employers of engineering graduates in the noncreative technology areas. However, there has been a steady growth in the absorption of engineering graduates in distribution and sales of both technical and consumer products. Even the investment community is finding engineers of value.

This country is unique in the free world in the broad scope of its use of engineering graduates in its economy. It seems that this broad use of engineers is one of the major factors in building this nation's unique economic and industrial strength. While the engineering graduate of Western Europe has, on the average, a greater depth of training than his counterpart in this country, the number trained is relatively much less than those trained here, and substantially all of them are used in professional engineering activities. As a result, their service, manufacturing, and distribution industries are heavily staffed, even at management levels, by men of less training, and operations are bound much more by tradition and relatively unimaginative conservatism.

It is most important in the interest of national strength that any changes in engineering curricula to better prepare the engineer for a career in creative technology have no adverse effect on the availability of men of engineering training for the noncreative technology places in the country's economy now occupied by the engineer.

The present engineering curricula are largely adequate in their amount of basic science and fundamental engineering for careers other than in creative technology. As our engineering curricula are given more depth in basic science and in fundamental engineering for those planning a career in creative technology, those planning other careers should not be subjected to the rigors of these disciplines. This might be accomplished through providing an elective at the beginning of the junior year for those destined for creative technology in which basic science and more rigorous fundamental engineering are given maximum emphasis.

The character of industry's training programs for graduate engineers in the noncreative technology areas largely supports the view that present curricula are adequate in their science and engineering content. In the training courses for such engineers, the emphasis is in nonprofessional engineering areas. Orientation courses to introduce the young engineer to his new environment are general. Courses in economics, business management, psychology, and labor relations are elements of most of these programs.

In recent years, an increasing number of industries are sending specially selected engineers of some 10 years' experience in the business to a graduate school of business for a year's training at company expense. The larger companies, especially among those nationwide in scope, are establishing training courses at a central point for specially selected men of comparable maturity. These training programs again emphasize the development of management potentials from both the economic and human relations aspects. Such training programs now vary in length from one to several months.

The Mechanical Engineering of Dielectrics

BRYCE MAXWELL

The proper selection and design of dielectric components for electronic applications must take into consideration the types of loading to be expected and the ambient temperature. It is suggested that 3-dimensional plots of the engineering properties vs. both time and temperature are necessary for best results.

THE PRIMARY CONSIDERATION in the design of dielectric components in the electronic industry must be the electrical characteristics of the materials used, but it is equally important that the component do the mechanical job required. It is of little use to have a component well designed from the insulation point of view if structurally it is unsound and will fail due to distortion, fatigue, impact, creep, abrasion, or deterioration due to poor aging characteristics.

New developments in the field of dielectrics are taking place rapidly today, particularly in the high polymeric materials. The understanding of the scientific principles which govern the electrical properties of these materials has progressed much more rapidly than the understanding of the fundamentals of the mechanical properties.

BASIC CONSIDERATIONS

EACH POLYMERIC MATERIAL exhibits a transition temperature below which it is rigid and glass like. Above the transition, it is soft and more rubbery. Some materials can be used below their transition temperature, for example polystyrene, and others are used above, for example polyethylene. In the transition region the properties of the material change rapidly, hence the first design consideration would be the determination of the transition region and the selection of a material that does not have its transition in the temperature range to which the component is expected to be subjected.

Once this is determined the next consideration would be the conventional engineering properties such as modulus, strength, thermal expansion, etc. If the material selected seems suitable in these respects the next consideration is the more specific mechanical engineering properties, for example impact strength, abrasion resistance, fatigue, and hardness. In these properties plastic materials do not behave in a manner similar to the more conventional materials that the structural engineer is familiar with.

The inter- and intra-molecular cohesive forces which determine the mechanical response of a polymeric material are made up of many types of primary and secondary chemical bonds. Each of these bonds may be thought of as analogous to a spring (elastic element) and a dashpot (viscous element) connected in parallel.[1] That is, the behavior of the gross material will be like a group of these parallel models in series. It becomes evident then that

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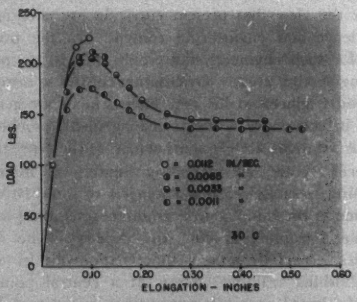
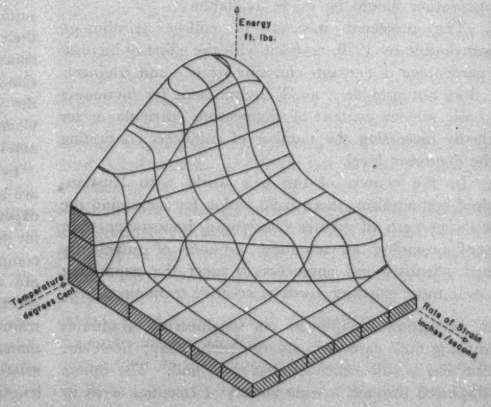


Fig. 1 (above). Load-deformation curves for methyl methacrylate at various rates of straining. Fig. 2 (right). Impact strength of methyl methacrylate as a function of temperature and rate of straining



for any given temperature there will be some specific relaxation time associated with each type of bond. Therefore if a mechanical load is applied to the gross material, the rate at which it is applied will be very important. If applied slowly, many bonds will have time to deform and the specimen will absorb more energy. If the rate of application of load is rapid, the bonds with the longer relaxation times will not have time to deform and the failure will take place without the absorption of as much energy.

Similarly if a small sinusoidally oscillating load is applied, only those bonds whose relaxation times correspond to frequencies faster than that applied will be able to deform. Therefore, the modulus of elasticity will increase rapidly when each type of bond is frozen out as the frequency is increased. There will be a peak in the energy absorbed at the resonant frequency of each bond involved.

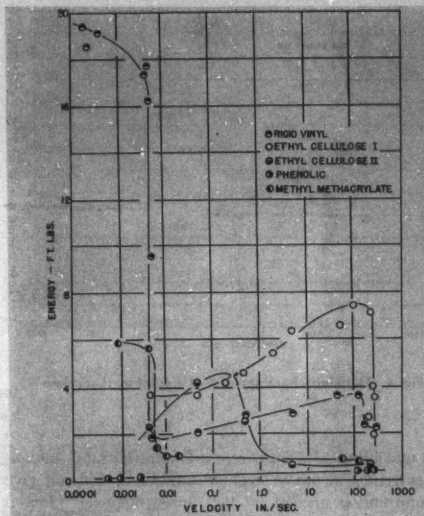
For determination of design data, the test temperature should correspond to the expected use temperature since the relaxation time of each bond will be dependent on the temperature. In general, an increase in temperature will decrease the relaxation time but all types of bonds are not affected to the same extent.

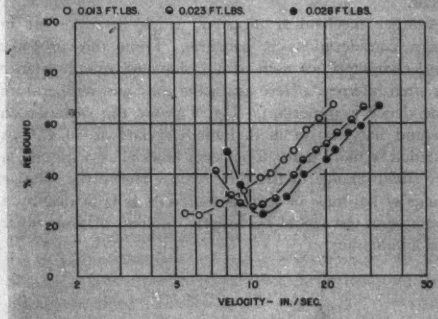
MECHANICAL PROPERTIES

IT IS APPARENT from the afore-mentioned that the mechanical properties of polymeric materials cannot be described in terms of specific values for each property as is commonly the practice for more conventional materials such as metals, but rather the variation of the properties with time and temperature must be known.

The variation of the yield point and ultimate elongation of methyl methacrylate with rate of straining[2] is shown in Fig. 1. Although only a rather limited range of rates of loading are shown here, it is apparent that the yield point decreases with a decrease in the rate of straining and at the same time elongation increases. If these results are extrapolated, the long time strength will be much lower than the value indicated by a conventional tension test.

Many of the failures in the dielectric components in electronic applications take place due to impact or shock loading. It is popular to think of impact strength as that quantity of energy absorbed by a standard specimen in a standard test performed on a pendulum-type machine. Inherently such a test is limited to a very narrow range of rates of loading, but the impact behavior of plastics is dependent on the rate of straining. Fig. 2 shows the behavior of methyl methacrylate when subjected to various rates of straining at temperatures from 30 C to 90 C.[2] Two distinct regions of rapid change in the energy absorbed are discernible. That is, two distinct regions where the impact strength decreases rapidly. The first drop which appears at lower rates of straining is associated with the bonds involved in chain-chain slipping. The drop at higher speeds is associated with the bonds that restrain





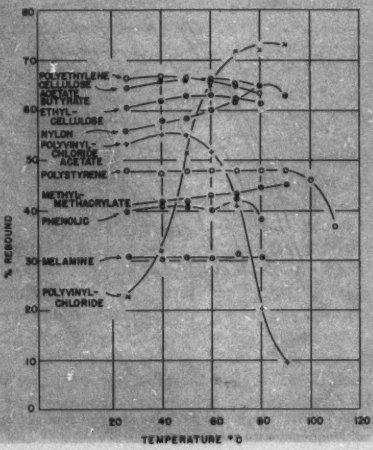


Fig. 3 (top). Impact strength of various materials as a function of rate of straining. Fig. 4 (center). Rebound hardness of methyl methacrylate as a function of rate of indenting. Fig. 5 (right) Variation in rebound hardness with temperature

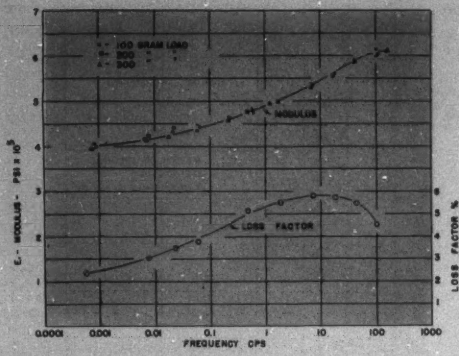


Fig. 6 Dynamic characteristics of methyl methacrylate

chain uncoiling. It is apparent a 1-point spot test, such as that currently in use to evaluate materials, will not give the information needed by the design engineer. Fig. 3 shows similar data at 30 C for several other plastic materials.

Another mechanical property which is important in design considerations is hardness. From this property other characteristics such as abrasion and mar resistance are often inferred. Here again the time and temperature dependence is important. Fig. 4 shows the variation in rebound hardness of methyl methacrylate at 30 C.[4] A variation of more than 50 per cent takes place with only a very small change in the time scale. Hence the relative ratings of hardness of various materials as indicated by a 1-point spot test would be entirely different at some other rate of indenting.

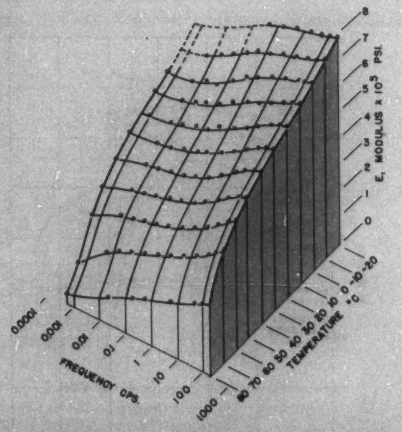
The variation in rebound hardness of various materials as the temperature is changed is shown in Fig. 5. There is no consistent change with temperature, thus illustrating that each material must be studied independently over its useful temperature range.

Many applications of insulating materials in the electronic field place the dielectric under an alternating stress. For example, an insulator rigidly fixed to a chassis at two points will be subjected to a force which will oscillate with the changes in temperature. These forces may oscillate at daily, yearly, or ON-OFF frequencies, or be subjected to higher frequencies due to nearby oscillating equipment.

The mechanical response of methyl methacrylate to an oscillating applied stress is shown in Fig. 6.[5] As the frequency is increased, the modulus goes up. At the point where the rate of change of the modulus is greatest there is a maximum in the loss curve. That is, as the frequency is increased in this region the natural frequency of a bond system is passed, and above its natural frequency only deformations with faster relaxation times can take place. The variation of the modulus of this material with both temperature and frequency is shown in Fig. 7. The corresponding changes in loss factor are shown in Fig. 8.

Failure due to fatigue will be greatest in regions where the loss factor is high. The large peak at low frequency and high temperature is associated with the glass transition and shows very clearly why this material is not applied in that range. At lower temperatures and higher frequencies, one secondary maximum and the indication of another appear. These regions should be avoided in design consideration.

Since it is possible to take the dynamic data shown in Figs. 6, 7 and 8 much more easily than the data on the other engineering properties, it would be desirable to find some method of predicting the specific properties from the dynamic data. Since each maximum in the loss curve



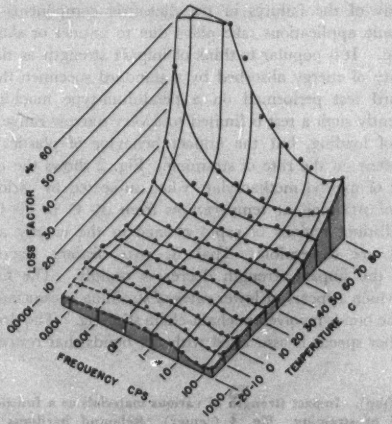


Fig. 7 (left). Dynamic modulus as a function of frequency and temperature. Fig. 8 (right). Loss factor as a function of frequency and temperature

represents the natural frequency of a bond system such a correlation should be possible. This constitutes a current research problem.

CONCLUSIONS

THE MECHANICAL ENGINEERING of dielectric components for electronic applications cannot be attacked by the same methods used for more conventional materials. The effects of time and temperature must be considered in reference to the types of loading to be expected and the ambient temperature. It is suggested that proper selection and design can only be accomplished after consideration of 3-dimensional plots of the engineering properties vs. both time and temperature. It is hoped that such information on specific engineering properties can be deduced from dynamic tests obtained in sinusoidal forced-oscillation tests.

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Explosion-Proofing Instrumentation Equipment for Flight-Test Use

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This article deals with the prevention of explosions in flight-test airplanes caused by flight-test instrumentation equipment. While considerable progress already has been made, much remains to be done in the way of investigation, education, and the application of information already known. This is where the instrumentation manufacturer is invited to participate.

IN THE DEVELOPMENT of modern aircraft, much progress has been made recently in aircraft structural design, power plants, control systems, and navigation and communications systems, all of which has resulted in an airplane having a high degree of safety and reliability. Keeping pace with these technological advances has been the constant improvement of equipment, particularly electrical, to make it explosion proof under all normal flight conditions. However, there remains a field of safety which deserves further attention; this is the field of flight-test instrumentation. This field is particularly important for two reasons: first, airplanes to be flight tested carry the responsibility of determining the changes and improvements to be made on the many future airplanes upon which the security of our country depends; and second, flight-test instrumentation must often be installed in areas too hazardous for conventional electrical equipment.

The flight testing of today's airplanes requires many complex instrumentation systems and equipment. At the present time, the aircraft industry has for its use only measuring and recording equipment designed primarily for use in laboratories or other relatively nonhazardous areas. Some of this commercial instrumentation equipment can be readily modified to make it operable in the extremes of temperature, vibration, and shock encountered in flight-test work, but until recently, little attention has been given to the risk created by operating test equipment in the presence of explosive vapors. As long as airplanes are propelled by combustible fuel, there will be occasions when fuel leaks will develop and result in a hazardous condition unless all the equipment exposed to this fuel or vapor is explosion proof.

While the qualifications necessary to classify aircraft electrical equipment as explosion proof differ from the standards established by the various authorities concerned with industrial equipment, a very high degree of safety is maintained by conforming to aircraft explosion-proof standards, such as are defined in the Military Specification *E-5272A*. There is no doubt that the industrial standards for explosion proofing are as good as or perhaps better than aircraft standards; however, the aircraft industry cannot accept the space and weight penalty imposed by large or heavy enclosures and still fly the airplanes. This is a very important point deserving careful consideration. Adequate explosion-proof protection can be obtained in most cases

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B. F. Hager is with Boeing Airplane Company, Seattle, Wash.

without adding greatly to the weight and space of an item by a careful study of aircraft conditions and preventive methods.

EXPLOSIVE ENVIRONMENT

First, consider the environmental conditions necessary for or conducive to an explosion within an airplane. Assuming that a source of ignition is present, such as improperly protected electrical equipment, an explosion is likely to result if the atmosphere surrounding the point of ignition contains a mixture of air and fuel falling within the set of conditions shown in Figs. 1, 2, and 3. Fig. 1 shows that at a given temperature, 59 F for example, a fuel-to-air ratio of from 1.3 to 7.5 per cent can produce an explosion. The figures given are for butane or propane gas because this is the fuel used for test purposes, however, the ratios for aircraft fuel are similar.

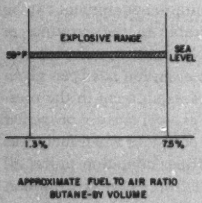
Within this range of fuel mixtures, the probability of an explosion is dependent on several factors, one of which is the temperature of the explosive atmosphere. Fig. 2 shows that the hotter the gaseous mixture, the wider is the range of fuel-to-air mixture for an explosive condition.

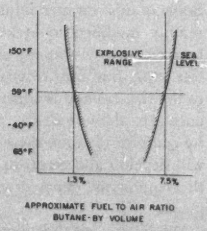
Another factor which influences the probability of an explosion is the altitude or ambient pressure of the combustible mixture. Fig. 3 shows the effect of altitude on conditions necessary to produce an explosion. While high altitude gives greater security by reducing the probability of an explosion, high altitude may be a disadvantage because of the fact that the dielectric properties of air decrease with low air pressure, creating a condition which may cause an arc.

Other factors which influence the probability of an explosion are the electrical energy in the arc, the shape of arcing surfaces, and the material in the contacts. Other things being equal, a high-energy spark is more likely to cause an explosion than a low-energy spark, and the longer the arc, the greater is the probability.

To assist in the proper explosion-proof evaluation of electrical equipment, tests have been conducted to determine the length and diameter of an opening through which flame must pass to be sufficiently cooled to render it incapable of igniting an explosive mixture at the other end. While the effectiveness of a particular size of opening is partially dependent on the volume of the initially exploded area, the temperature of the outer mixture, and the type of material through which the opening passes, it is possible to design a vent which will effectively suppress flame and prevent propagation of an explosion. A commercial product called the Lisk Disk has been found to provide a very effective flame-cooling and venting path. This is a small cylindrical section into which is fastened a honeycomb of thin corrugated stainless steel providing many separated flame-arresting paths. Its action is similar to that of a flame suppressor on the carburetor of a marine engine. Another material called Poroloy appears to offer possibilities in this direction. This is a compressed sintered-stainless-steel wire mesh, making a porous but strong sheet.

In dealing with the explosion-proof problem, it must be assumed that the following conditions will exist at some time during the flight testing of an airplane. A mixture of fuel and air falling within the combustible ranges just discussed will be present. This explosive mixture will find its way into instrumentation equipment not hermetically sealed. The penetration of this gas into equipment is assisted by the normal turbulence of the air so necessary for proper ventilation, or by the breathing of the equipment because of altitude changes. It must also be assumed that a spark or heat from the normal operation of the equipment will explode the gas within the part. However, the destructive effects of the heat and pressure from the explosion within can be completely eliminated by allowing the hot gas of the explosion to be vented through a flame-cooling passage of adequate design.





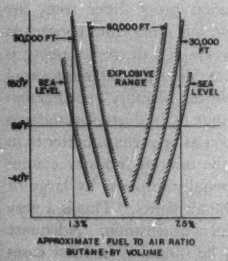


Fig. 1. (top left). Range of probability of explosive mixtures. Fig. 2 (top right). Effect of temperature on the probability of explosion. Fig. 3 (left). Effect of altitude on probability of explosion

TESTS AND TEST EQUIPMENT

Considerable information about ways and means of explosion proofing has been obtained by carefully controlled tests. Fig. 4 shows a small chamber having a volume of approximately 2 liters, which is used to determine the explosion-proof status of such components as switches, push buttons, thermostats, and similar small parts. The item to be tested is placed inside the chamber which is provided with tubing and valves to allow replacement of clean air with a mixture of gas known to be within the explosive range. Butane or propane is used as the test gas because it is known to have similar but slightly more combustible characteristics than the commonly used airplane fuels. This gas also disperses readily and maintains a homogeneous mixture.

The chamber is evacuated to approximately 1 pound per square inch absolute (psia), and then the air and gas are fed in. The air and gas are carefully controlled and thoroughly mixed as they are drawn into the chamber by means of the vacuum already created. In this way,

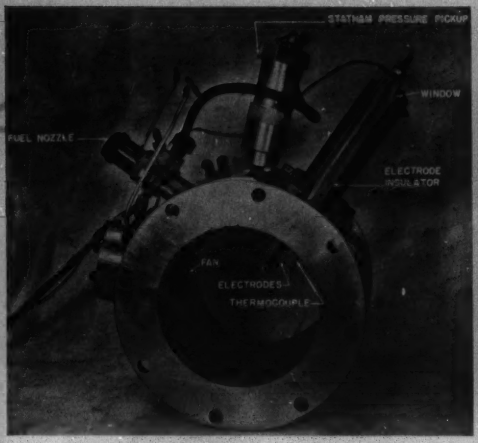


Fig. 4. Small explosion test chamber (2 liters)

Fig. 5. Large explosion test chamber (47 cubic feet)

penetration of the gas mixture into the test item is assured. A spark is produced within the test item either by creating an arc across internal contacts, mechanically actuating the test item to simulate its normal operation, or by energizing a tiny sparkplug previously installed in the part being tested. In order to determine, beyond any doubt, that an explosion is actually created within the test item, a tiny thermocouple is installed through the case of the part and is connected to a recorder. When an explosion occurs within the test item, the chamber is observed to determine whether the explosion damages the test item or propagates through openings in the item and explodes the surrounding gas. If no explosion of the outer mixture occurs, a pair of points are energized with 20,000 to 30,000 volts to check the combustibility of the outer gas. The exploded gas is then drawn out and replaced with a fresh mixture known to be within the combustible range and the test is repeated. Each item is tested in this way for at least ten times at each of several different fuel mixtures within the combustible range.

If, after many tests, none of the explosions in the test item ignite the gas mixture in the chamber and there are no apparent reasons for doubting the validity of the test, the item is considered explosion proof. This procedure includes or surpasses all the explosion-proof test procedures required under the Military Specification *MIL-E-5272A*, Section *4.13*, Procedures *1* and *2*.

Fig. 5 shows a larger explosion test chamber which has a volume of 47 cubic feet and has facilities for reducing the inside air pressure to below 1 psia, or the equivalent of higher than 80,000 feet. This chamber also contains accurate fuel-measuring equipment and high-capacity pressure relief valves. It can be quickly purged of exploded gas and set up for the next test. Large motors or assemblies of arc-producing equipment can be tested in this chamber.

By applying the information thus gained, it is possible to utilize one or more of the following methods to prevent an explosion or restrict propagation of an explosion into a hazardous area: the item can be hermetically sealed; it can be vented by proper heat-dissipating air passages; the temperature of heat-producing parts can be held to safe limits (below 450 F); or an assembly of items can be made explosion proof by proper selection of components incorporating these qualities.

EXPLOSION-PROOF MODIFICATIONS

Some simple modifications made to instrumentation components have changed them from hazardous items to explosion-proof items without impairing their operation or adding greatly to their size, weight, complexity, or cost.

Fig. 6 shows some components frequently found in airborne flight-test equipment. All these pieces of equipment are well designed and perfectly satisfactory for most normal conditions, but they are explosion hazards when used in their original condition in aircraft. Operation of this equipment in an explosive atmosphere can produce an explosion and result in complete destruction of the airplane.

Fig. 7 shows the same type of equipment in explosion-proof condition. The relay, item *1*, has been replaced by a hermetically sealed relay, which not only eliminates the explosion problem but improves reliability in general. Hermetically sealed versions of most small relays are readily available, so this presents no serious problem except that the manufacturers of some equipment are still a little reluctant to use sealed relays. The motor, item *2*, has been reinforced by changing the shape and the material of the header. The leads are brought out through glass feed-through connectors. A Lisk Disk has been installed in the cap to relieve pressure resulting from an explosion, and to allow the escaping gas to be cooled below the ignition temperatures.

The solenoid, item *3*, has been made explosion proof by replacing the original pull-in coil switch with a low-travel switch of a type found to be explosion proof. The

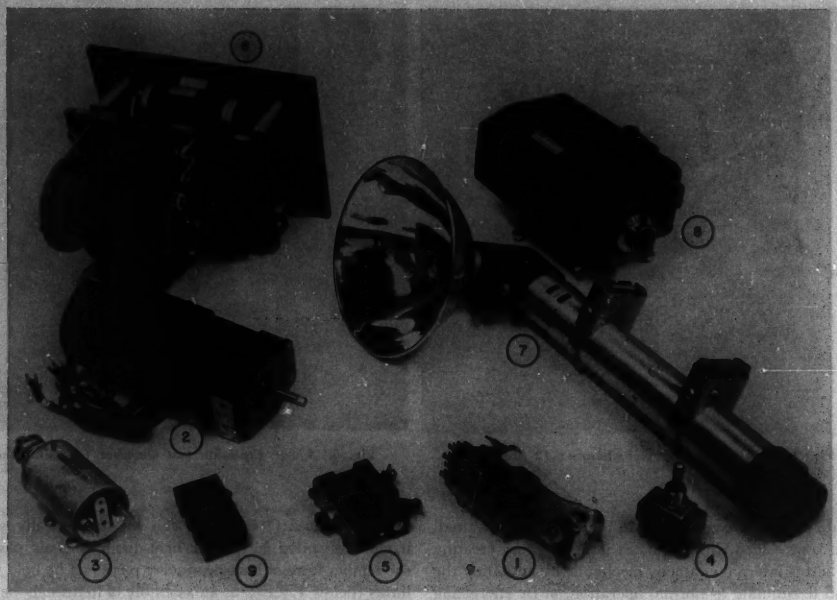


Fig. 6. Typical hazardous items used in flight-test instrumentation

Fig. 7. Hazardous items made safe by explosion-proof modification

toggle switch, item *4*, has been replaced by one from a different manufacturer who, perhaps without realizing it, made his switch explosion proof in an effort to make it more resistant to moisture and dust.

This circuit breaker, item *5*, has been chosen in preference to the other hazardous type because it has been proven to be explosion proof by tests. The voltage regulator, item *6*, has been modified to increase the wattage and lower the temperature of the resistors which formerly operated in the range of 600 to 700 F. This change also results in improved reliability and general performance.

The flash gun, item 7, has received more elaborate treatment, but the principle is the same. An explosion-resistant housing has been built around the original flash gun and a long vent or flame path has been provided, the outlet of which is a Lisk Disk. The reason for this special treatment is that if the flash bulb explodes, the heat energy of the source of ignition is so high that when added to the heat of combustion of the enclosed gas, the result is an explosion of very high heat and pressure.

Item 8 is a remotely controlled camera containing an unprotected electric motor. The case of the camera is not explosion resistant so a box, with mounting studs attached, has been built to enclose the camera. The box is vented by a Lisk Disk, which allows the use of lighter metal than would otherwise be acceptable.

Fig. 8 shows some components, frequently found in instrumentation equipment, which might be suspected of being hazardous were it not for the fact that tests have proved these items to be explosion proof as long as they are used within their design ratings.

At this time it is felt that considerable progress in explosion-proofing flight-test instrumentation equipment has been made. However, there are still items of hazardous electrical equipment which need further attention. In the absence of a satisfactory modification, arc-producing equipment to be mounted in a hazardous area can be completely housed in an air-tight enclosure, which in turn is constantly purged by a source of clean dry air at a pressure slightly higher than the air pressure surrounding the enclosure. This method has at least three definite disadvantages: first, the added space and weight of the enclosure; second, requirement of the equipment to be in an enclosure complicates servicing, adjusting, or reloading during a test flight; and third, a constant reliable source of clean dry air of correct pressure is not easy to find in an airplane. A ram air pickup scoop is one solution, but not a good one. A compressed-air or CO_2 bottle is another possibility, also with obvious disadvantages. Locating the equipment in a nonhazardous area might be satisfactory, if such an area were to be found without making the equipment itself inaccessible.

CONCLUSION

THE best place to begin explosion proofing is, of course, with the manufacturer of the test equipment. Here, much can be accomplished by the proper selection of components in the original design or, in some cases, by a simple modification of existing equipment. It can be concluded, however, that explosion proofing of flight-test instrumentation equipment is not impossible nor is it as difficult as it might seem without investigation.

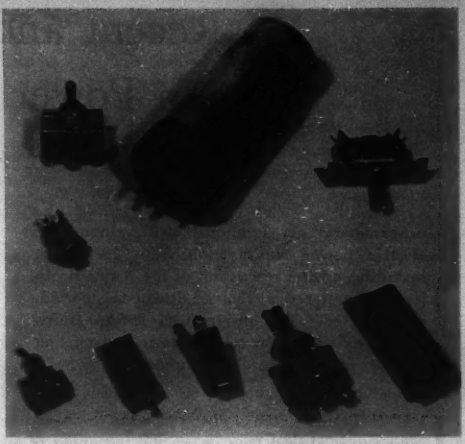


Fig. 8. Typical electrical components found to be safe by tests

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Constant Lighting for Camera

An automatic iris, which electronically compensates for changing light levels to assure television pictures of constant brightness and contrast, has been announced by the Radio Corporation of America. Developed for use with RCA's *ITV-6* closed-circuit system, the iris automatically provides constant lighting for the camera's Vidicon pickup tube regardless of external light levels. The iris mechanism masks the lens with the proper filter for any given external light condition. The automatic iris, which resembles a roll of 35-mm film, is mounted with motor-driven regulators on the front of the *ITV-6* camera. The film serves as a filter and is continuously graded in density, from clear to heavy. The camera's Vidicon pickup tube responds to the intensity of external light striking it. With corresponding intensity, the Vidicon activates the iris control mechanism which, in turn, triggers the motor regulators on the camera. The motors automatically unreel the film between the lens and the Vidicon tube until the filter of proper density is in place.

Recent and Past Progress in Power Transmission

PHILIP SPORN
MEMBER AIEE

A summary of significant achievements in electric power transmission from 1900–1945, including a brief discussion of the major problems encountered and solved during this period, is presented. The progress of 330-kv transmission today and the role of power transmission in the future is emphasized.

THE IMPORTANCE of giving mobility to power was understood abroad long before the beginning of an electrical industry. The art of applying power in industrial operations had its origin in Europe with the industrial revolution. Since the locus for optimum generation did not necessarily coincide with the locus of use, the achievement of mobility was recognized as an indispensable means of utilization or of increasing efficiency. In consequence, more than a century ago, efforts were made in England, France, Germany, and Switzerland to transport power from point of generation to point of use.

In these early efforts water under high pressure, compressed air, and wire rope were utilized to move hydraulic power. Distances ranged from a few thousand feet to miles. But the technology of transmission received revolutionary impetus with the first commercial central power station in 1882, and the perfection of Stanley's a-c transformer in 1886.

As the electric power industry grew, the technology of transmission altered and improved. But, whereas growth and improvement in the art of generation has been a fairly continuous process, at times developments in transmission have been spasmodic. In the period of standstill the forces of necessity which ordinarily stimulate invention and pioneering were lacking. The flexibility inherent in a-c transmission, with which we are all familiar, made it possible to carry the greatly enlarged loads at various times with facilities built and developed for smaller loads.

Yet this flexibility has its limits. With loads and systems expected to increase four to five times in the next 25 years, more than ever it is important that what has been accomplished in the past be used to take bearings on where we stand and to try to project a sound course ahead.

EARLY DEVELOPMENTS IN TRANSMISSION

THE EARLY PIONEERING IN TRANSMISSION occurred when industries, beginning to use more and more power, were prevented from using attractive water-power resources because power could not be moved an appreciable distance. An example of the urge to give power mobility during the decade 1880–1890 was the flood of proposals for large-scale development at Niagara Falls, and the realization that the value of the power would be increased immeasurably if some way could be found to carry it the 22 miles to Buffalo. In 1887 the City of Buffalo offered a prize of $100,000 for the best transmission scheme. However, none of the mechanical systems proposed, most of which were based upon European installations, was acceptable and no award was made. In 1886 at Great Barrington, Mass., Stanley had already carried single-phase power 4,000 feet with a transformer stepping up to 3,000 volts at the source and stepping down again to 500 volts at the load. But this was too new and electric transmission was not yet recognized as the only answer to the Niagara problem.

The International Niagara Commission organized in 1890 fared no better. Its organizer was Edward Dean Adams, president of Cataract Construction Company, which later became Niagara Power Company, and the Commission included among its five members the famous Lord Kelvin. The Commission invited leading manufacturers and scientists to submit proposals for a 125,000-hp development and transmission to Buffalo. By 1891, 17 proposals had been made but none was considered adequate without radical changes and no first prize was given, although a number of prizes were awarded.

Meanwhile other projects for moving hydro power were getting under way elsewhere, particularly on the Pacific coast. In 1890, 480 kw of single-phase power at 4,000 volts and 125 cycles were carried 14 miles from Willamette River Falls to Portland, Ore. In 1892, single-phase power generated at San Antonio Canyon, Calif., was stepped up to 10,000 volts and carried 14 miles to Pomona, marking the first commercial use of step-up transformers.

Based on these developments and demonstrations, the directors of Niagara Power Company selected a-c transmission in 1893 for the Niagara-Buffalo project. And in 1896 that company completed the first 11,000-volt, 25-cycle transmission line over the 22-mile distance. In 1898 there was also placed into service the 30,000-volt 3-phase 75-mile line from Santa Ana Canyon to Los Angeles and, in 1899, the 40,000-volt 70-mile line from Colgate Hydro to Sacramento. Thus, major progress occurred in the decade 1890–1900.

SIGNIFICANT ACHIEVEMENTS 1900–1920

AT THE TURN OF THE CENTURY, electric power transmission was firmly established and progress was rapid. Using pin-type porcelain insulators, voltages were increased to

Revised text of a paper presented at the Twenty-third Annual Convention of the Edison Electric Institute, Los Angeles, Calif., June 16, 1955.

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60 kv by the Pacific Gas and Electric Company in building a 150-mile line from Colgate to Oakland in 1902. During the next 5 years, many more lines were constructed at this voltage by the Pacific Gas and Electric Company and the Edison Electric Company, both in Calif. The Edison line, built in 1907, extended 117 miles from Kern River to Los Angeles. By 1910, the Pacific Gas and Electric Company had in operation over 1,000 miles of 60-kv lines, serving some 150 communities from 11 generating stations with a load totaling 100,000 kw.

Maximum transmission voltage was unchanged from 1902 to 1908 because of the limitation of the pin-type insulators. In 1907 Hewlett and Buck developed the first suspension-type insulators and made possible a break through to higher voltages. In 1908 the Grand Rapids Power Company in Mich., using the new insulators, pioneered a 110-kv line which covered 50 miles from Grand Rapids to Muskegon. Other lines in this voltage class soon followed. The Central Colorado Power Company built a notable 100-kv 150-mile line over the Argentine Pass. Because of the high altitude, 13,600 feet, and the small 1/0 copper conductor size with resulting corona loss, this line was limited in its operation to 95 kv.

During the next decade voltages were raised to 140 kv. In 1912, the Ausable Electric Company constructed a 125-mile line of that voltage from the Cook plant on the Ausable River to Flint, Mich. The following year, the Pacific Light and Power Corporation boosted the level to 150 kv. That company, which later became Southern California Edison, built its 240-mile 150-kv line consisting of two single-circuit towers from Big Creek to Los Angeles. Many other lines in the 110- to the 132-kv class were constructed during the 1910–1920 period. By 1920 the mileage of these lines throughout the country was extensive.

LATER DEVELOPMENTS, 1920–1945

AT THE SAME TIME that lines at voltages up to 150 kv were being installed, studies were proceeding for 220-kv transmission among several groups, including Southern California Edison, Pacific Gas and Electric, and Electric Bond and Share. The Southern California Edison project involved the conversion of the Big Creek 240-mile line from 150 to 220 kv. In preparation, a 27-mile section was isolated, grading shields were added, and tests were made at 241 and 284 kv to determine corona performance, charging kva, and the general feasibility of using existing towers and insulators. Corona losses on the 0.96-inch diameter conductor energized at 278 kv measured from 15 to 45 kw per mile depending upon the weather, and agreed quite closely with calculated values using Peek's formulas. Charging current values were found to be $7^1/_2$ per cent higher than calculated. Corona loss at 241 kv was negligible in clear weather and only about 3 kw per mile in rain. Using autotransformers for step-up and step-down between 150 and 220 kv, the actual cutover of the line to 220 kv was completed on May 6, 1923, marking the first operation of a transmission line at this voltage anywhere in the world.

Following inauguration of 220-kv operation in Calif., Pennsylvania Power and Light undertook a similar project linking Wallenpaupack Hydro with the Siegfried Station near Allentown. It was subsequently extended to Plymouth Meeting at Philadelphia, the receiving end of Philadelphia Electric's Conowingo 220-kv line. An extension was then made from Plymouth Meeting to the Roseland Station of Public Service Electric of N. J., and in 1932 from Roseland to Bushkill, a tap point on the Wallenpaupack–Siegfried line. The construction of these lines over the years 1926–1932 created the 3-company Pa.-N. J. power pool, an event notable in the history of interconnected system operation.

While a considerable mileage of 220 kv had been built before 1935, tremendous expansion was taking place everywhere at lower transmission voltages. In New England, New York State, in a number of Southern states, and in the Pacific Northwest 110 kv predominated. The American Gas and Electric Company and others in the Middle Eastern states from Va. to Ill. built extensive 132-kv systems. Elsewhere, such as in the Tennessee Valley Authority area, 154 kv was becoming prevalent.

An important step in perfecting still higher voltage was the project undertaken in the early '30s by the Department of Water and Power, City of Los Angeles. The problem was the delivery of power from Hoover Dam, Nev., to Los Angeles, a distance of 270 miles. Investigation of this project and the design of the transmission system involved study and research in corona performance and investigations of various types and sizes of conductors, at various voltage levels and under varying weather conditions. These investigations were carried out largely at Stanford by Carroll, Cozzens, and Blakeslee. The project also required studies of stability and power limits, which became primary considerations in the final selection of the transmission voltage. An integral part of the investigation was the development of the high-speed, 3-cycle circuit breakers for switching, that is for opening (but not reclosing) the line.

SOME OF THE PROBLEMS ENCOUNTERED AND SOLVED

A COMPRESSED CHRONOLOGICAL ACCOUNT of the development of transmission is likely to give a deceptive impression of the ease of solution of problems along the way. Actually the difficulties were formidable in designing, building, and making operative the right equipment, in learning how to cope with rain, sleet, and lightning, and with such phenomena as corona, arcing, and instability.

Although the pioneering work was not uniformly distributed among the utilities, it is amazing how widespread were the centers of major advances over the years—Niagara, Calif., Colo., Mich., Ohio, and Pa. are but a few. Almost always the pioneering reflected joint effort by utilities and manufacturers. In the rapid advances in the art, perhaps no factor has been more important than the easy availability to anyone of discoveries and the experience integrated by all investigators.

Of the many problems that had to be mastered to bring transmission to the mature stage it had reached in 1945, the following ten were among the more important:

1. *Insulators.* The porcelain suspension insulator of today and the high quality of its performance could not be visualized by the pioneers who were forced to use glass

because of the unsatisfactory moisture-absorbing characteristics of the early porcelain-pin product. A series of developments led to today's insulator. First came the work of Locke in developing the wet-porcelain process, of Hewlett and Buck in inventing the clevis suspension unit, and of Austin and of Ohio Brass with the cap and pin unit. There followed Austin's work on treated sanded surface and the resilient pin to give flexibility in the steel-cement-porcelain combination. Continuity of control in every step was promoted by the work of a number of utility engineering organizations as they devised testing procedures for insulators before installation and during active life while the line was alive.

Since about 1916 insulators have ceased to be a barrier to advances in transmission, but a great deal of work has been carried out in the interval by manufacturers and utility engineering organizations to produce the refinements which have been needed to keep pace with the requirements of higher voltages. And the work is not yet ended.

2. *Lightning.* The story of studies of lightning carried out co-operatively by the utilities and the manufacturers during 1925–1955 is a saga in itself. Here only a brief review is given.

The studies began 30 years ago at a point not much more advanced than Franklin's knowledge. By now investigations have covered frequency, amplitude, character, time, rate of rise, current and voltage of lightning; they have explored the lightning characteristics of wood, porcelain, air, and other dielectric media; they have developed remedial devices, including ground wires, counterpoises, expulsion tubes, and ultra-rapid reclosure as well as many other improvements in apparatus. These advancements virtually have removed the destructive menace of lightning. The work that still remains to be done exists only because we are still pushing forward the frontiers of the art of transmission itself.

3. *Circuit Breakers.* Nowhere in the record of power transmission is there a more striking achievement than the developments associated with switching electric circuits and building electric switches. The beginning was the fused Niagara–Buffalo high-voltage lines where fuses were found to be slightly wanting; it led through the Pacific Gas and Electric Company tubs, to the 25-million kva 330-kv breakers installed on the American Gas and Electric Company and Ohio Valley Electric Corporation systems, today capable of carrying a current of 2,000 amperes, circuit opening in 3 cycles, and circuit reclosing in 15 cycles after the initiation of a fault.

The steps in between were, of course, manifold. Among the outstanding ones was the idea of an arc-generated gas pressure; the concept of deionization; the idea of speed; the impulse idea to assure adequate clearing of low-current faults; and the concept of ultra-rapid reclosing of a circuit breaker.

In all this work the manufacturers and the utilities co-operated. This is particularly true in the case of field testing of circuit breakers. Among the companies which did pioneering work are Baltimore Gas and Electric, Pennsylvania Water and Power, Commonwealth Edison Alabama Power, Ohio Power, Pacific Gas and Electric Bonneville Power Administration, and many more. The result of such work is the modern breaker. Up to now, the United States has the disadvantage of accompanying oil. But by a repetition of the kind of program carried out in the past, we should be able in the future to develop a new series of breakers capable of doing the job without oil.

4. *Relaying and Ultra-Rapid Reclosing.* It took a long time to obtain general acceptance of the idea that relaying and switching may have more to do with determining how many and what kind of transmission lines are needed to deliver a specific block of power, than conductor size and other physical characteristics of transmission facilities. This is not surprising. It was natural to think of a relay as performing the function of giving an impulse to disconnect a line in trouble, and for a breaker to carry out that function upon receipt of the impulse. And, the line having been disconnected, what more natural than to wait until all trouble is cleared before re-energizing the line? It required a mature art to conceive the idea that the function of a relay–breaker combination is to disconnect the line in trouble and then reclose it with the minimum possible delay, perhaps so fast that no effect of interruption has taken place. Both the utilities and the manufacturers again played significant parts in perfecting this idea.

Starting with relatively crude devices like selective time-delay relays, there followed numerous balanced schemes for duplicate lines, reverse power schemes and, when need for speed became apparent, instantaneous over-current schemes. There culminated, finally, the thought that what was needed was a differential scheme, the same idea that had proved so successful in the protection of generators and transformers. This was originally proposed in a balanced phase arrangement using carrier current as a pilot. This idea proved unreliable in tests, but Ohio Power adapted the idea by using carrier for comparison of direction of power flow by standard or conventional relays. By this step, relay time was brought down first to 3 cycles, later to 1 cycle; this paved the way for the ultra-rapid reclosure of lines up to 330 kv in a matter of 15 cycles from initiation of fault. This significant development reduces by more than 90 per cent the circuit outages that would otherwise occur; but it is still some distance from perfection. Further refinements are under way, and will undoubtedly lead to improvements as loading of circuits increases with use of higher voltages.

5. *Frequency and Load Control.* The functioning of modern transmission circuits is dependent on a system of stable frequency control and on load or line regulators. Results have been achieved by the work of progressive manufacturers, and the co-operation between technicians of many companies, hundreds, and even thousands of miles apart. While a great deal of equipment was used in this work, certainly the critical piece was the impedance-bridge-type graphic frequency recorder, developed by Leeds and Northrup and first introduced in the load dispatcher's office in 1925. Today normal frequency is considered frequency with a deviation of no more than ±0.10 cycle,

absolute time deviation allowance is taken as ± 3 seconds; and if the frequency is above 60.10 or below 59.90 cycles something is done to restore it to normal value and it is done on the basis of distributing the regulation burden among the systems operating in parallel. Standards of this kind have made possible the successful parallel operation of such large power groups as the Interconnected Systems Group, which had a combined simultaneous 1-hour peak in 1954 of over 35½ million kw.

6. *Communication and Carrier Telephony.* Carrier telephony, for the past quarter century considered indispensable in the operation of transmission networks, had its beginning in the work of Tidd, Sindeband, and Milnor, which led to an installation on the system of Atlantic City Electric in 1920. This was followed by commercial sets, and the use of these spread quickly. Their growth was accelerated by the adoption of coupling capacitors and single-frequency communication. The success of carrier in communication led to its use in telemetering and in control. Carrier current now supplies a basic demand more reliably than any other means of communication and control for high-voltage networks. Yet because of the crowding of the spectrum, eventually it will be relegated to a feeder role, the principal transmission to be taken over perhaps by a system of micro-wave. In fields other than main communication, however, carrier use seems likely to continue to furnish an indispensable tool in any extensive transmission system.

7. *Sleet Detection and Melting.* One of the difficult problems which has always confronted the operator of a transmission network in the United States is the formation of ice or glaze on conductors. This "sleeting" results from temperature inversion with the surface of the earth below freezing while the upper air is above freezing, permitting precipitation as rain to form ice when it strikes the cold transmission conductors. The mechanical stresses imposed upon towers by icing are dangerous enough. Frequently even greater danger results from the "dancing" or "galloping" of conductors which icing causes.

Improvements in mechanical design rendered structures safe in many cases but did not solve the problem of outage of line. This was tackled very early by methods designed to remove ice. Some of the first efforts in this direction were carried out between Baltimore and Holtwood on the line of Pennsylvania Water and Power, by special generating arrangements that made possible the flow of a heavy reactive current. But such arrangements limited the application of this method. Large interconnected networks gave rise to arrangements for sleet melting by utilizing the voltage of the system for connecting sufficient line in series to give a proper impedance to connect between the system voltage and ground. This means of melting sleet on the 132-kv system of American Gas and Electric has been used since 1938. The same methods were used recently on its 330-kv transmission lines by impressing a voltage of 130,000 volts on a section of 330-kv circuit and bringing about a flow of 1,450 amperes, power of 30,000 kw, and almost 350,000 kvar. One of the great additional steps in fighting ice has been the system of detection of sleet formation by measuring the dropoff in carrier signal strength received over a transmission line as sleet begins to form on it. This work, originally carried out by Langdon and Marquis, has been perfected over the years and is used now on many systems.

Generally in this field, while the technology is adequate to cope with a difficult problem, it is clear that room for further development exists. Perhaps we shall devise a nonsleet-adhering conductor, or other means for repelling moisture.

8. *Synchronous Condensers and Static Capacitors.* The importance of the reactive or excitation component of an alternating current and of being able to generate this component independently by means of condensers—synchronous or otherwise—was observed very early. Application of equipment to supply the need, however, was relatively slow. The only facilities available for the purpose were rotative machines and these machines themselves presented great difficulties. The combination of high losses, excessive noise, difficulty of ventilation and need of buildings to house the apparatus had adverse effects on the economics of application. In 1913 synchronous condensers were installed in Los Angeles by Southern California Edison, in 1916 on the Windsor-Canton line of Ohio Power, and in 1919 on the system of Pacific Gas and Electric. But the burden that the synchronous condenser carried with it was not lightened until 1928 and 1929. In 1929 Ohio Power successfully installed a conventional condenser outdoors. An even more significant step had occurred in 1928 when the first two hydrogen-cooled synchronous condensers were installed, one by New England Power at Pawtucket, and the other by Appalachian Electric Power at Turner Substation. These led to a series of such condensers which quickly took advantage of the possibilities of reducing size, noise, losses, cost of installation and maintenance, and improving the reliability inherent in the hydrogen design. These advantages were carried to higher levels by bringing up pressures and simplifying auxiliaries.

While this progress was being made in rotative machines, new technology for building static capacitors was introduced about 1932 and opened up a new field of application for this apparatus. Here kraft paper and nonflammable dielectric were the keys to cost reductions. The developments were furthered by the work of a number of utility organizations in pushing direct connection of capacitors to high-voltage buses, up to 110,000 volts. There is no reason why this cannot be carried much further. The development of the series capacitor, which was retarded for a long time by the unavailability of application owing primarily to the relative scarcity of long lines, was opened up in the early part of 1950 by the application in a number of installations on the lines of the Bonneville Power Administration. Thus, the full range of the static capacitor has been explored, and the way paved for its further exploitation in the lines of the future, particularly if more interregional lines of very high voltage are built.

9. *Power System Stability.* Although the problem of stability—that property of a power system which insures

that it will remain in operating equilibrium through normal and abnormal conditions—was encountered in the early '90s, the phenomenon was not appreciated for a long time.

The problem first began to be understood in the 1920's as a result of analyses by Vannevar Bush and later extended by Bush and Booth in their so-called step-by-step method of analysis. This was followed by the significant work of Fortescue, Wagner, Evans, and their colleagues, and by the work of Doherty, Nickle, Park, Jones, Treat, Crary, and their co-workers. From this and other work done on a number of utility systems, there evolved finally the modern concepts and understanding of the integrated effect on stability of generator, transformer, and transmission line impedance, excitation systems, speed of relaying and speed of clearing and reclosing lines, the effect of condensers, the effect of governing, and the effect of the characteristics of the load served and its protective system. In all of this work, the aim has been clear: to produce a situation where instability or threatened instability would be no barrier to the maximum utilization of the transmission facilities. We have achieved now a high state of understanding of the problem and while work is not finished we do know how to design and build with minimum threat of disturbance from stability problems.

10. *Corona and Radio Noise.* The luminescence, audible noise, and the nature of the ionization within dielectric media due to electrostatic stress have been the subjects of various opinions and extensive tests dating from the first knowledge of electricity. With later observations came the knowledge that energy waves propagate from discharges caused by overstress. The early investigations of Lichtenberg in the 18th century were followed by those of scientists of the 19th century, among them the famous Sir Humphry Davy. They were picked up in the development of the art of movement of power by Tesla and Steinmetz in the 1890's. However, toward the end of the last century, Mershon at Telluride, Colo., was perhaps the first to carry out work on corona and to develop data on loss due to corona. The work of Peek, Whitehead, and Ryan followed in the next 25 years.

Originally corona and related phenomena were examined only from the standpoint of losses in transmission. With the coming of radio, corona and associated phenomena assumed today's more important aspect as a source of interference. And as corona took on this more important aspect, there also came a better understanding of the role of the insulator and the conductor as a source of interference particularly in inclement weather. Carroll, investigating this problem on the Boulder Dam–Los Angeles line in the middle '30's, had a full appreciation of this problem. Other important investigations on the subject were carried out in obtaining the basic information for, and in design and construction of, the American Gas and Electric 330-kv system and of the Ohio Valley Electric Corporation 330-kv system. We now know that it is corona and associated radio influence that may become the most important, perhaps the sole obstacle, to free extension of overhead high-voltage lines operating at 330,000 volts and above. Work on this subject is by no means complete.

THE DEVELOPMENT OF 330-KV TRANSMISSION

In 1946 it became evident that existing transmission voltages, particularly 132 kv and below, would become inadequate within a few years. Higher voltages were necessary to (1) restore flexibility and balance between capacity of individual generator units and transmission circuits, (2) avoid excessive costs and difficulties in securing the multiplicity of rights of way for continued expansion at lower voltages, and (3) reduce the basic cost of transmission.

In our own system a substantial increase in capability could have been attained by adopting either 230 or 287 kv, already in use. We concluded, however, that we needed a still higher voltage that would remain adequate for another 30 to 40 years, in other words commensurate with the period served by the then-current voltage. To determine the new voltage, and design, a basic research program including a full-scale field line installation was projected. We contemplated investigating corona, lightning performance, radio influence, sleet melting, feasibility of maintenance, and so on. With the wholehearted cooperation of several manufacturers we then set up the Tidd 500-kv test project, including two 1.4-mile single-circuit variable-spacing steel tower lines, instrumentation, lightning arresters, and step-up transformers with variable taps from 265 to 532 kv. The test program, as described in the literature, provided corona loss and radio influence data at various voltages on many sizes, types, and spacings of conductors under year-round all-weather conditions. Concurrently with this program, studies were carried out on basic insulation level, line insulation, tower and hardware design, future planning, and transmission economics.

The Tidd tests showed rather early that radio interference rather than corona loss would dictate conductor diameter, and the economic studies brought out the decided cost advantages of double-circuit lines. Decisive factors in the design, therefore, narrowed down to (1) the highest voltage for which double-circuit construction appeared practicable, (2) a voltage for which the conductor diameter needed for radio interference would not be excessive for sleet melting or handling, and (3) an insulator string length not excessive for hot-line maintenance.

These considerations led to an initial choice of 315 kv nominal (330 kv maximum), 1.6-inch diameter, 1,272,000-cm expanded steel-reinforced aluminum-cable conductor, 18 5¾-inch line insulator units, and a transformer basic impulse insulation level of 1,125 kv. Bundled or twin conductors were considered but ruled out at that time because of sleet melting and maintenance considerations.

The first line, a 60-mile section from Sporn plant, W. Va., to Kanawha River plant, one circuit on double-circuit towers was completed and placed into service at 132 kv in 1952. A similar section, 50 miles from Sporn to Muskingum River plant, Ohio, completed and placed in service early in 1953, was the first to be stepped up to a voltage of 340 kv in October of that year.

Unexpectedly high levels of radio influence, mainly due to excess saturant from conductor filler, along with insufficient care in handling, stringing, etc., made it desirable to cut the line back to 132-kv operation following a short period of testing. An immediate review of the radio inter-

ference situation led to a decision to increase the conductor diameter, particularly for the impending Ohio Valley Electric Corporation lines, from 1.6 inches to 1.75 inches, giving a greater radio interference margin. Conductivity was increased about 11 per cent above the old conductor. At the same time, line hardware, sleeves, joints, etc, were rechecked in the laboratory for radio interference characteristics, modified where necessary, conductor manufacture and handling methods were improved, a more rigid inspection procedure was adopted, and both wooden horses and tension equipment were used in stringing new lines to avoid abrasion of conductors. To meet revised radio interference limits, operating voltage level on the modified 330-kv lines was restricted to 328 kv.

Construction of lines with 1.75-inch conductor was started early in 1954. Today the entire Ohio Valley Electric Corporation transmission system, approximately 400 miles of double-circuit lines, is in service at 328 to 330 kv.

Radio interference levels have been about as expected for new lines, but complaints have been negligible, even from locations approaching suburban areas where particular concern was felt.

While the modified conductor was used throughout the Ohio Valley Electric Corporation system, some 300 miles of line on the American Gas and Electric system were too far along with 1.6-inch conductor to make the change. It was, therefore, decided that these lines, Tanners Creek to Fort Wayne, Ind., to East Lima, to Muskingum River, Ohio, would be completed and operated at 290 to 300 kv initially by means of autotransformers at Tanners Creek and Muskingum River where the loop closes on 1.75-inch conductor. Two 400 mva autotransformers were ordered for this purpose. It is expected they can be dispensed with later at these locations, as conductor aging results in radio interference improvement. The autotransformers may then be used as "aging" transformers elsewhere.

An encouraging experience occurred this spring when the original Sporn-Kanawha line, which had been strung with the same batch of contaminated 1.6-inch conductor that had given trouble in 1953 on the Sporn-Muskingum River line, was energized at 330 kv. Apparently conductor aging even at only 132-kv operation, was sufficiently effective to bring 330-kv radio interference to satisfactory levels. Hence this line was left in permanent operation at 330 kv.

Altogether, there are now in service at 330 kv some 400 miles of double-circuit lines on the Ohio Valley Electric Corporation system and 260 miles on the American Gas and Electric system. The latter has another 230 miles still under construction.

Operating experience to date has been good, although lightning flashovers have somewhat exceeded predictions. During a severe sleet season, ice was melted successfully on one 330-kv line section. On another section, where melting current is not yet available, "dancing" conductors caused a rather prolonged outage, thus emphasizing the importance of sleet-melting procedure on 330-kv lines.

LOOKING AHEAD

In the light of the rate of growth of utilty loads, and the coming quadrupling of these loads over the next 20–25 years, and the increase in the size of generating units being developed to meet that growth, there is an urgent need for the utilities to plan for grealty increased capacity for power transmission.

How well 330 kv can meet this future challenge may be judged by considering the capability of a typical 135-mile line. Assuming eventual operation, after conductor aging at 345 kv, loadings of 500 megawatts on one circuit or 1,000 mw on a double-circuit line are feasible. In the short period of service that 330 kv has had on American Gas and Electric and Ohio Valley Electric Corporation systems, integrated loadings of 350 mw per circuit have actually taken place. And if a twin-conductor, double-circuit design should be adopted—an attractive possibility from the standpoint of resistance to conductor "dancing" and from the standpoint of radio interference characteristics—these capabilities would be increased by at least 25 per cent to 625 and 1,250 mw respectively. This is more than eight times the capacity of existing double-circuit 132-kv lines.

Such capabilities offer savings so high in the avoidance of future inadequacies of service and are, therefore, so important that the larger investment in high-voltage lines today can be an act of prudence. Taking such action will in the end serve best everyone concerned, including consumers and investors.

It is of the utmost importance that we start to develop the higher voltage networks now. But to start a new voltage on any power system involves initially large capital outlay. The engineers, charged with the responsibility of developing systems at minimum costs, naturally hesitate before taking such an ambitious step. They look to management to tell them to go ahead and do it; management on its part looks to the technicians; old voltages tend to be continued when new ones ought to be initiated.

Now, however, we have reached a stage on many systems where the facts are so clear that management and technicians together should be able to discern that higher voltages are essential. This is a time, in short, when it is the job of management to give the engineers a policy that will enable the technicians to begin to plan, to build, and to operate the transmission that will be needed tomorrow and in the years ahead.

The step-up is not going to be easy. We should bring along personnel; we need to carry out further laboratory investigations and develop our technique of actual installation. If the utilities of the country become convinced of the operating urgency to bring about, and of the economies inherent in, the future movement of power at higher voltages, then enough will have been done to be able to make the start now and many of the detailed plans and developments can be worked out as we proceed to generally bring movement of power at much higher voltages into a reality.

If we do not make that start now, we risk foreclosing the route that eventually will be best from a technical and an economic standpoint; we risk finding ourselves overcrowded because of the proliferation of lines that lower voltages require, and with no space available for the much more effective users of space that high-voltage lines in fact are.

Charts for Calculating Locomotive Performance

R. D. CHARLTON
MEMBER AIEE

TO DETERMINE the success of a locomotive application, it is desirable to evaluate the effect on locomotive performance of both system and locomotive constants. In the process of designing an 11,000-volt 25-cycle rectifier locomotive, a generalized graphical method was developed for calculating speed-tractive effort curves, and evaluating relative importance of system and locomotive constants.

In an idealized locomotive—infinite bus at trolley, infinite inductance in motor circuit, no resistance, and no reactance on the a-c side of the rectifiers—calculation of speed is straightforward. The applied alternating voltage is expressed in terms of its average value after full-wave rectification. As there are no losses, this voltage is traction-motor counter emf, and determines speed when motor characteristics and motor current are specified.

The addition of ohmic resistance requires that the average voltage loss in resistance drop be subtracted from the applied average voltage before speed is determined.

The addition of locomotive reactance X_B requires that the phenomenon of rectifier commutation be treated analytically. A means is determined to calculate the volt-seconds lost to the traction motors during the commutating period, expressed as an average voltage. This average voltage E_X is $2IX_B/\pi$.

The addition of system reactance X_A complicates the determination of the average value after full-wave rectification of the alternating voltage applied at the locomotive pantograph. During rectifier commutation the applied trolley voltage departs from a sine wave. The rapid reversal of current in the line or system reactance causes a voltage drop which drives down the trolley voltage during commutation. Ratio of average to rms voltage f_a is

$$f_a = \frac{1+a+\cos\theta(1+a)}{2+(1-a^2)\left(1/4\ \sin 2\theta - \frac{\theta}{90}\right)^{1/2}}$$

where a is the ratio of locomotive reactance X_B to total reactance $(X_A + X_B)$, and θ is the commutating angle. Current

$$I = \frac{(1-\cos\theta)}{2f_r}\ \frac{e_r}{X}$$

where $X = (X_A + X_B)$, e_r = rms trolley voltage, and

$$f_r = \left\{\frac{1}{\pi}\left[\frac{\pi}{2} + (1-a^2)\left(1/4\ \sin 2\theta - \frac{\pi\theta}{90}\right)\right]\right\}^{1/2}$$

The term $(1 - \cos\theta)/2f_r$ can be plotted with θ as the abscissa and a as the parameter for a family of curves. For any value of θ there is a corresponding value for f_a.

For any value of traction-motor current (with values of e_r and X known), the rectified average value of applied trolley voltage can be read out of the two families of curves, for any particular value of a. A per-unit system is employed using arbitrary base values. The several kinds of voltage drops—resistance drop, commutating reactance drop, rectifier-tube drop, motor-brush drop—can all be plotted as families of curves using selected base values, with voltage as the abscissa and traction-motor current as the ordinate. By selecting vertical scales with some care, the voltage-drop curves may be vertically aligned with the families of commutating angle and average voltage.

To expand the use of families of curves for commutating angle and average voltage, geometrical construction can be made to relate the actual quantities under investigation to the quantities used in constructing the families of curves.

The complete construction for a representative example is shown in Fig. 1. The line voltage is 8,000 and $(X_A + X_B)/e_r$ is 139 per cent of base. For the value of motor current assumed, it can be seen that the average voltage for speed is about 640. A comparison of calculated and test values for the same circuit shows a maximum speed error of 3 per cent over the range of values likely to be encountered.

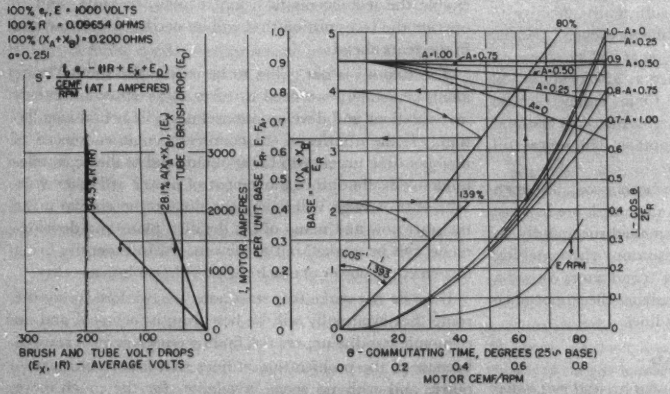

Fig. 1. Complete graphical construction

Digest of paper 55-209, "Graphic Aids for Calculating Rectifier Locomotive Performance," recommended by the AIEE Committee on Land Transportation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Published in AIEE *Applications and Industry*, July 1955, pp. 189–94.

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The Struggle for Unity

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The history of the various efforts directed toward unity is briefly summarized. A plan of action is offered which appears to have merit and seems worthy of consideration by those who are searching seriously for an effective unity organization.

HUMAN BEINGS have inhabitated the earth for a million years or more but the great scientific and engineering achievements that have built our fabulous push-button age have come about for the most part in the past 75 years—the lifetime of an individual. Our engineers and scientists have accomplished miracles in this short space of time, but all of the scientific and engineering brains that have produced our great civilization of today, have been unable to accomplish what should have been a relatively simple goal: unity in the profession.

Unity did exist in the profession at one period but for a very short time. The Institution of Civil Engineers was founded in England in 1828. "Civil" then meant all engineers other than military. Its membership was then, and still is, open to all engineers, but *only* to engineers. In 1848, the Boston Society of Civil Engineers was formed, which like the Institution of Civil Engineers in England, was designed for membership of all engineers.

WHY UNITY?

OUR FIRST national engineering society was the American Society of Civil Engineers founded in 1852. In a few years, the mining engineers started their own organization. This was the beginning of "splintering." They were followed by the mechanical engineers, electrical engineers, chemical engineers, and others, until today there are more than 70 separate engineering societies which well may be called "National Engineering Societies." The Directory of Scientific and Technical Societies published by the National Research Council lists nearly 1,300 such local and national organizations in the United States. In these 100 years, there has been no single group that could claim to represent the entire profession of engineering. Pages and even books have been written expounding on the need for unity. Mr. W. Ryan of The American Society of Mechanical Engineers (ASME), when speaking to the Boston Section of ASME in January 1954, summarized all of these dissertations in a few simple sentences. He said, "We want to unite to secure recognition of engineering as a profession and its importance in our American economy. We want to have unity for cultivation of ethical practices, for the acceptance of our professional responsibilities. We wish to unite in efforts to raise the economic status of the engineer, not through union labor practices, but through sheer recognition of his value. We want to be in a position to defend ourselves against harmful legislation, to have our opinions respected in regard to military affairs and public works. We want to be heard on matters affecting technical education and the registration of engineers." Surely no one will take issue with these simple statements of the need for unity.

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THE AMERICAN MEDICAL ASSOCIATION

CONSIDER the American Medical Association (AMA). There are dissenting opinions with the AMA, and some doctors are not even members of the organization. The medical profession, like the engineering profession, has its subdivisions of special professional interests. However, AMA still speaks with authority for the medical profession. Frequently, articles appear in print with the notation below the article caption, "Approved for publication by the AMA." (This is not an autocratic approval, but an endorsement desired by the author.) In the minds of laymen and professional men alike, this stamps the article with authenticity, clothes the subject matter with concurrence of the medical profession, and concedes to the author a voice of authority.

Admittedly the problem of recognition has been simpler for the medical and legal practitioners, as they are generally self-employed and in constant contact with the individuals who make up the "public." The greater proportion of engineers are salaried and usually do not come in contact with the public in the practice of their profession. This materially complicates the unity problem and that of professional recognition for the engineering profession. The AMA is not offered as the perfect example of a unity organization, since it has weaknesses in its structure as well as outstandingly strong points. However, it is a real unity organization, and the engineers in their struggle for unity can do well to study the AMA to avoid the undesirable features that have developed in the AMA experience with their plan.

SOME STEPS TOWARD UNIFICATION

FROM TIME TO TIME there have been limited steps toward unification within the engineering profession. Twenty years ago the Engineers' Council for Professional Development (ECPD) was formed with representation from the "Four Founder Societies"—AIEE, ASME, American Institute of Mining and Metallurgical Engineers (AIMME), American

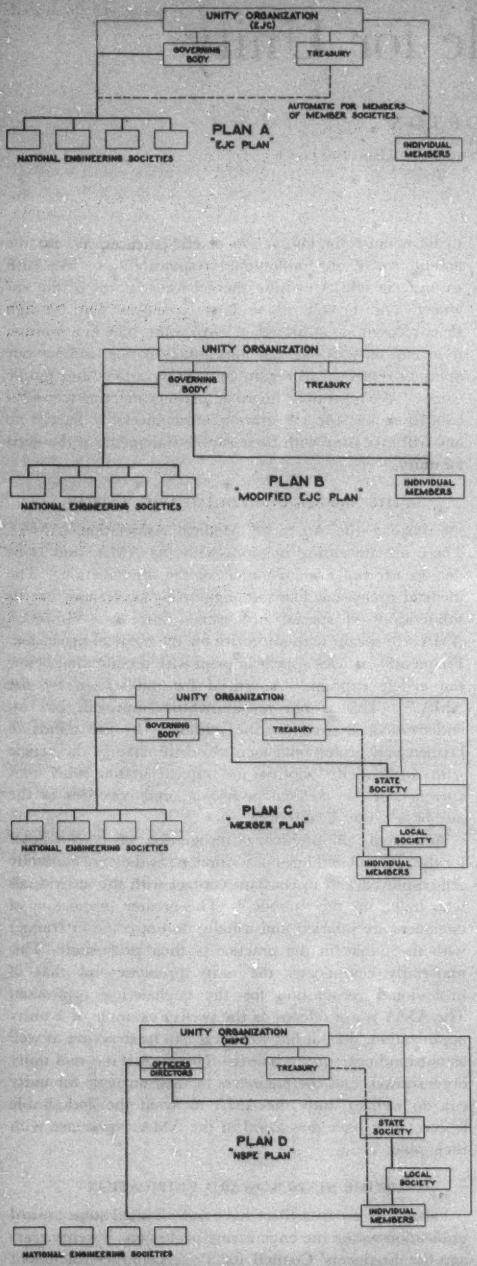

Fig. 1. The four plans submitted by the original Exploratory Group. The dotted lines indicate principal financial support of the unity organization

Society of Civil Engineers (ASCE)—and from the Engineering Institute of Canada, the American Society for Engineering Education, and the National Council of State Boards of Engineering Examiners. While its best known activity has been that of dealing with accrediting of engineering curricula, the activities of ECPD have covered a much broader scope, such as the guidance of young persons entering the engineering field, encouragement and assistance to young engineers in their technical studies, orientation of the young engineer in industry, and the creation of a Canon of Ethics that has become the standard for many engineering societies. So outstanding has been the accomplishments of ECPD in activities directed toward advancement of the professional status of the engineer, that its work is fully endorsed by all technical societies.

Another action toward unity was in the field of standards when the American Engineering Standards Committee was organized in 1920. It later became the American Standards Association, and its splendid work is supported by all of the major technical societies.

In 1904 the gift by Andrew Carnegie of funds for the erection of a headquarters building for the engineering societies prompted an early step in the direction of unification. On the initiative of ASME, AIMME, and AIEE, the United Engineering Society was incorporated by the legislature of the State of New York for "the advancement of the engineering arts and sciences in all their branches and to maintain a free public engineering library." ASCE joined the Founder Societies in 1916. The 1904 corporation, now known as United Engineering Trustees Inc., (UET) administers the Headquarters building, the Engineering Societies' Library, and the Engineering Foundation which is a research organization founded in 1914 by Ambrose Swasey of Cleveland, Ohio, for "the furtherance of research in science and engineering, and the advancement in any other manner of the profession of engineering and the good of mankind." UET also administers several other trust funds for the profession and acts as fiscal agent for ECPD as well as for several research councils sponsored by the Founder Societies. (AIEE Treasurer, W. J. Barrett, is President of UET.) It is not unreasonable to hope that when a new Headquarters building, now under study by the Founder Societies and the American Institute of Chemical Engineers (AICHE), is erected many more societies will wish to become part of the new engineering center—a further move in the direction of unity.

All of these steps are a gratifying indication of almost universal recognition of the need for concerted action and the need for complete unification, but they represent only a minor start toward unity. True, a form of unity of purpose does exist within the specialized fields of each technical society, but this is a long way from complete unity of the profession and a weak instrument for professional recognition.

ADVENT OF ENGINEERS JOINT COUNCIL

THE NEAREST APPROACH to representation of a large segment of the profession is in Engineers Joint Council (EJC) and its predecessor—the American Engineering Council. The American Engineering Council was formed in 1920 and

was disbanded in 1940. In 1941, EJC was formed as a Council of Presidents and Secretaries of the Four Founder Societies, AIEE, ASME, ASCE, and AIMME. They were joined by the American Institute of Chemical Engineers (AICHE) in 1942.

As the scope of EJC activities expanded, the "Conference" was felt to be inadequate, and the name was changed to "Engineers' Joint Council" in September 1945. Numerical representation of the constituent societies on the council was increased and a formal constitution was adopted.

THE EXPLORATORY GROUP

To STUDY means of accomplishing a unity organization, in 1949 a committee of EJC on Increased Unity Within the Engineering Profession was formed. As a result of meetings of this committee, the Exploratory Group was formed, consisting of representatives from 15 national societies who attempted during 2 years of study to present a plan for unity acceptable to the engineering profession. Four plans were presented. See Fig. 1.

A. *EJC Plan*—Expand EJC to include other engineering societies which would be eligible under the existing constitution of EJC. Individuals would have no direct representation but would have automatic membership in the unity organization by virtue of being members of the component societies.

B. *Modified EJC Plan*—Expand EJC to include other engineering societies and also to provide for voluntary individual membership. With this plan, individuals of high qualifications as engineers could become members of the unity organization whether or not they were members of the constituent societies. (An alternate form of Plan B would require these individual members to be members of technical societies also.)

C. *Merger Plan*—This plan contemplated the merger of of EJC and of National Society of Professional Engineers (NSPE) into a single body and the expansion of the merged organization in the ways necessary to enable it to represent the entire engineering profession. Individuals meeting basic membership grade recommended by ECPD would be eligible for membership in the unity organization.

D. *NSPE Plan*—This plan proposed adoption of NSPE as the unity organization with an expansion of its membership and activities with the co-operation of other engineering societies. This plan would necessarily require modification of the present entrance requirements into NSPE, as now only registered engineers are eligible for membership in the society.

EJC AS UNITY ORGANIZATION

EXTENSIVE POLLS of AIEE membership indicated a strong preference for Plan C. The AIEE stand was then, and still is, that a true unity organization must be based upon:

1. Individual membership rather than a council of societies.

2. An organization clothed with power to act promptly when required.

3. An organization that would be adequately financed to accomplish its objectives.

Although the Exploratory Group did not mention a specific plan in its recommendations, it did recommend that EJC be set up as the unity organization, and pointed out the desirability of having some form of individual membership in any unity organization.

Thus, the equivalent of Plan A was adopted without individual membership in order that, as recommended by the Exploratory Group, "the unity organization be launched in the simplest possible way," but with the understanding that efforts would be made by the new unity organization to effect an acceptable plan for such individual membership. These efforts have been sincerely made, but general agreements within EJC on an individual membership plan have not been forthcoming and EJC remains a federation of societies, the form in which it was started.

After acceptance as the unity organization, EJC modified its constitution (it then comprised AIEE, ASME, ASCE, AIMME, and AICHE) to permit extension of invitations to additional societies to join EJC, and at the same time, provide for representation from the constituent societies proportional to membership of the societies.

EXPANSION OF EJC

INVITATIONS WERE EXTENDED on December 31, 1952, to eight additional societies to join EJC. Of these eight, three accepted the invitation and are now active members of EJC. They are: American Society for Engineering Education, American Water Works Association, and Society of Naval Architects and Marine Engineers. Two societies rejected the invitation: Institute of Radio Engineers (IRE) and NSPE. Three additional societies allowed the time limit of December 31, 1953, to expire without accepting the invitation. These three were: American Association of Engineers, American Society of Heating and Ventilating Engineers,* and Institute of Aeronautical Sciences.

In a letter rejecting the bid for membership, the IRE stated that their rejection was dictated by two basic policies of long standing. First, that IRE shall not engage directly or indirectly in legislative activity; second, that IRE, as a society, is not entitled to represent its members as individual members of the engineering profession or as a body in social or general professional matters, and shall not, as a society, take a stand even on technical matters.

In declining the offer for membership, the NSPE stated that "at this time, in accordance with the firm conviction of the Board, no organization can adequately represent the engineers of this nation, unless that organization is based primarily on individual membership and constituted to assure prompt and effective means of communication between the individuals from local or state units and a national governing body." The resolution went on to express the firm desire of NSPE to continue mutual efforts toward the most effective action possible between the two organizations. The joint committee on relations between EJC and

*Now "American Society of Heating and Air Conditioning Engineers." This organization has recently made application for membership in EJC.

NSPE was then formed, and is being continued by both organizations to further explore areas of mutual co-operation between the two societies. The relations between representatives of the two organizations have been most cordial and co-operative.

Recently, two additional societies have been accepted for membership in EJC. They are: American Society of Refrigerating Engineers (constituent member), and American Institute of Industrial Engineers* (associate member). Thus, the total membership of EJC is now ten societies, nine constituent members and one associate member. (See Fig. 2.) Representation on the EJC Board of Directors from the constituent societies is based on numerical society membership. Each constituent society having 15,000 or fewer members is entitled to one representative on the Board of Directors. Societies with over 15,000 membership are entitled to one member for each 10,000 or fraction thereof over the 15,000. Thus, AIEE with 49,000 members has five representatives on the Board of Directors, the largest representation. There is one alternate for each representative. The president of each constituent society is an ex-officio member of EJC Board, without vote.

*Societies meeting requirements for constituent member, but with membership of less than 5,000 are admitted as associate members.

EJC ACCOMPLISHMENTS

The objects of EJC, as expressed in its constitution, are as follows:

1. To advance the general welfare of mankind through the available resources and the creative ability of the engineering profession.
2. To promote co-operation among the various branches of the engineering profession.
3. To advance the science and profession of engineering.
4. To develop sound public policies, respecting national and international affairs, wherein the engineering profession can be helpful through the services of the members of the engineering profession.

In the short time of its existence, EJC has performed well in meeting these objectives. Due to inadequate means of communications with the individual members of the technical societies, few of those members are familiar with the objectives or the accomplishments of EJC. Some of

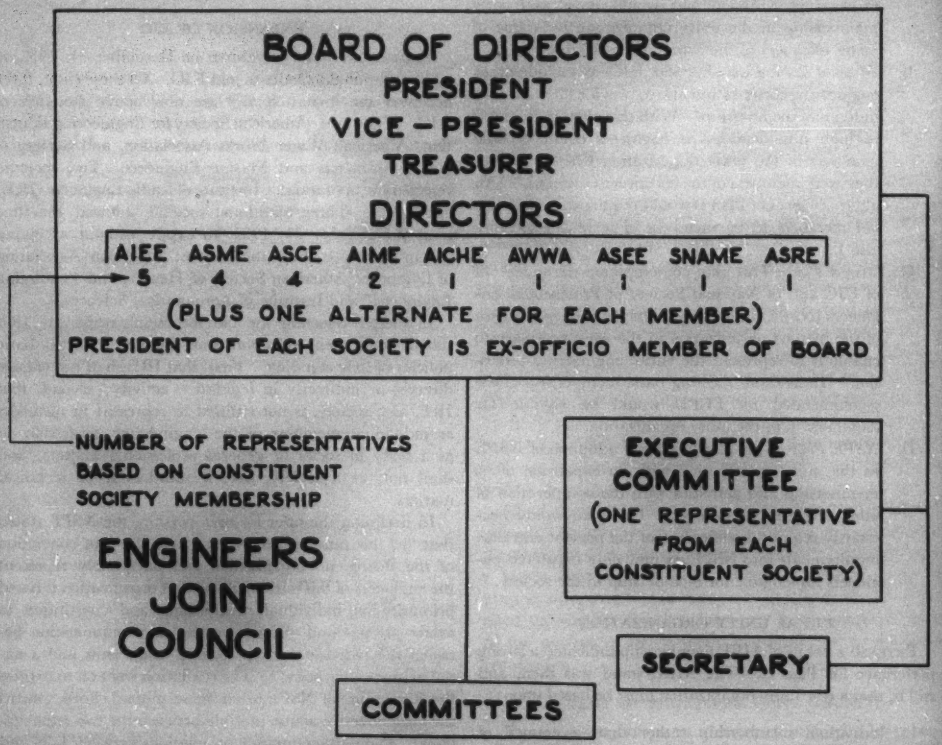
BOARD OF DIRECTORS
PRESIDENT
VICE – PRESIDENT
TREASURER
DIRECTORS
AIEE ASME ASCE AIME AICHE AWWA ASEE SNAME ASRE
5 4 4 2 1 1 1 1 1
(PLUS ONE ALTERNATE FOR EACH MEMBER)
PRESIDENT OF EACH SOCIETY IS EX-OFFICIO MEMBER OF BOARD
NUMBER OF REPRESENTATIVES BASED ON CONSTITUENT SOCIETY MEMBERSHIP
ENGINEERS JOINT COUNCIL
EXECUTIVE COMMITTEE
(ONE REPRESENTATIVE FROM EACH CONSTITUENT SOCIETY)
SECRETARY
COMMITTEES

Fig. 2. The present organization of Engineers Joint Council. Each constituent society has one representative on the Board for membership below 15,000 and one representative for each additional 10,000 or fraction thereof. There is one alternate for each representative

the many accomplishments of EJC include areas of the following:

a. Engineering Manpower Commission. Few engineers know about EMC, and fewer realize that it is a part of EJC. EMC working through ECPD, has done much to stimulate interest of secondary-school students in engineering careers. It has been very effective in preventing misuse of engineering manpower in the armed forces. It has become an authoritative clearing house for engineering manpower statistics. It has aroused an awareness in the Congress and in the Department of Defense of the value of engineers in the National Defense.

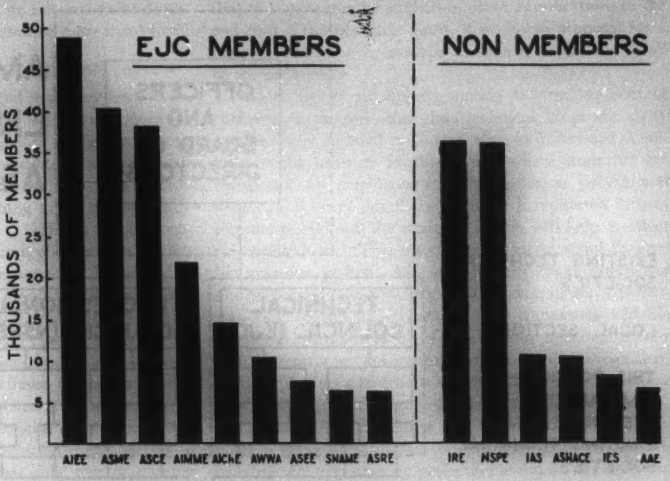

Fig. 3. The present status of the original 15 societies represented by the Exploratory Group. Nine are now constituent members of EJC and six are not affiliated. Not shown is the American Institute of Industrial Engineers recently admitted as an associate member

b. Atomic Energy Committee. EJC has taken a lead in the nuclear field by setting up a National Nuclear Congress to be held this year and is forming an Atomic Energy Committee for the co-ordination and dissemination of information including codes, standards, and the like among the constituent technical societies.

c. International Relations. EJC has acted as a co-ordinating agency between the United States and foreign countries in certain engineering matters of concern to engineers of both areas. It has worked actively with the Pan American Federation of Engineering Societies (UPADI) and is the United States member of UPADI. EJC has been an active member on the US National Commission of the United Nations Educational, Scientific and Cultural Organizations (UNESCO), which acts to encourage among American people the study of problems requiring international action.

d. Employment Conditions. Committees of EJC have been active in the collection and dissemination of information regarding employment conditions, relations with unions, and salaries of engineers.

e. Labor Relations. EJC Labor Relations Panel, in collaboration with others, notably NSPE, has been very successful in having the current professional provisions written into the Taft-Hartley Act.

f. Civil Service Commission. A committee of EJC, acting in an advisory capacity to the Civil Service Commission has rendered valuable service to the profession toward correcting certain inequities in classifications and salaries of Civil Service engineer employees.

g. Army Reorganization Legislation. A task committee of EJC was able to ward off legislation intending to classify all officers in the Army, except for categories of medical, legal and chaplain, as 100 per cent interchangeable. As a result of the work of this committee, the legislation was revised to include engineering as one of the "learned professions" along with the three previously excepted categories.

h. National Water Policy. After two years of work by a group of 80 engineers, EJC issued a statement of policy with respect to "Use and Conservation of National Water Resources," and copies of this document have been placed in the hands of every member of Congress and the Hoover Commission, to assist in developing a sound over-all water policy.

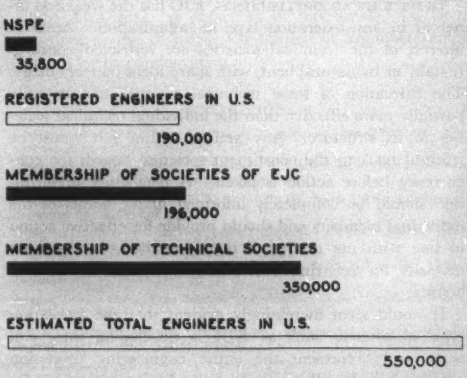

Fig. 4. Membership represented by NPSE, EJC, and the technical societies compared with the estimated total number of engineers in the United States. The totals of EJC and the technical societies are larger by 20 or 25 per cent, due to duplications of membership among the technical societies' rosters

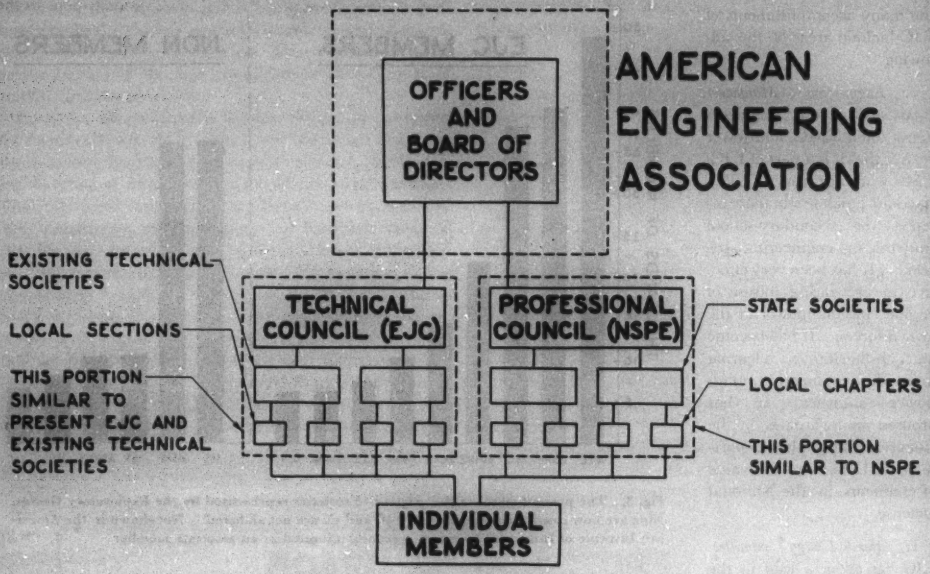

Fig. 5. The proposed "AEA Plan," which visualizes a unity organization to speak for the engineering profession. This plan proposes to make use of both NSPE and EJC as autonomously as possible, to form, with a co-ordinating Board of Directors, a unity organization to be known as the "American Engineering Association"

As realization of EJC's outstanding accomplishments becomes more widely recognized, more and more national and state engineering associations are becoming interested in affiliating with the Council. It is destined to continue to grow.

WEAKNESS OF EJC

DESPITE ITS ACCOMPLISHMENTS, EJC has the weakness inherent in any federation type of organization. Areas of interest of the technical societies are restricted constitutionally or by natural bent, with sharp focus on technology. The federation of these technical societies can be only partially more effective than the individual technical societies in its structure. Any actions within EJC must be referred back to the constituent societies' boards for concurrence before action is taken. A true unity organization should be completely informed of the wants of the individual members and should provide for effective action in line with the desires of these members, but without necessity for referring back to the constituent societies' boards.

It would seem increasingly evident that the federation type of council, such as EJC is developing into, can never truly represent the entire engineering profession adequately. It still appears that the basic requirement for any unity organization is "one that is based upon individual membership, adequately financed, and clothed with the power to act when necessary." It still appears that a closer and more direct line of communication with the grass-roots local sections or chapters, and with the individual members is essential where professional matters are concerned. Despite all this, EJC has a record of major accomplishments in the field of unity and until some other form of unity society is formed, EJC should be supported in its work by the members of its constituent societies.

MEMBERS REPRESENTED BY EJC

THE MEMBERSHIP of the 15 engineering societies as of May 1955, represented by the original Exploratory Group concerned with the unity problem is shown in Fig. 3. Those to the left are the 9 societies affiliated with EJC as constituent members; those on the right are the remaining 6 societies not affiliated with EJC. You will note from this chart that AIEE is the largest engineering society in the world with nearly 50,000 members and should take a leading part in the unity effort. If we are to have a successful unity plan, we need all of the engineering societies on this chart co-operating together.

Fig. 4 shows the total number of engineers in the United States estimated as over 550,000 and the membership represented in the technical societies as 350,000. This illustrates some of the problems in working out a plan of unity. It will be noticed that NSPE has 35,800 members or about one sixth of the 190,000 registered engineers in the United States. There are now 196,000 engineers represented by the membership of EJC. (Membership figures are exclusive of students but include some percentage of non-voting members, such as "Engineer-in-Training" mem-

bers of NSPE. These figures also do not recognize duplications, hence some members are counted more than once.)

THE NEED FOR NSPE IN A UNITY ORGANIZATION

THE UNITY PROBLEM can be stated in a very few words. Since we must have individual membership, and since we must have an organization that reaches to the grass roots, it would seem that we cannot have complete unity without the co-operation and tie-in with the NSPE, which already has a complete organization reaching down through state levels into local and county levels. NSPE is a going concern, which has a fine record of accomplishment in the advancement of the engineer professionally. However, in order to fully utilize the NSPE organization some compromises will, of necessity, have to be made so that NSPE can represent engineers who, at the present time, do not desire to register because registration is not a legal requirement in their work. This compromise is necessary until such time that a much larger proportion of the nonregistered engineers become convinced that registration of all engineers is a necessary step to complete recognition of engineering as a learned profession. It is evident that merely naming NSPE the unity organization, as some have suggested, is not the complete answer.

A NEW PLAN FOR UNITY

DURING THE PAST YEAR OR SO, a new plan for unity has been gaining favor. The new plan, Fig. 5, which could be called the "AEA Plan" appears to have a great deal of merit. The AEA Plan would maintain a Technical Council utilizing the existing EJC organization, which would handle at top level all of the technical problems affecting the entire engineering profession. Working together with this group would be a professional council utilizing the NSPE organization, which would handle all matters of a professional nature affecting all engineers. Each of these groups would be based on making use of presently set-up organizations as autonomously as possible; EJC on the one hand with its present setup, and NSPE on the other hand with its existing state societies and local chapters. Above these would be a Board of Directors which would co-ordinate the over-all policies of the two councils. This co-ordinating board and the two councils might be known as the "American Engineering Association." There would be no change in the prerogatives in the specialized fields now enjoyed by the technical societies.

In EJC and NSPE we have two going concerns, each organization now doing splendid work in somewhat overlapping fields. A logical question is asked, "Why not make use of both, rather than perpetuate the present situation that leaves us divided instead of unified?" Unless we make a determined effort to unify what we have today, with a will and determination to work gradually toward the idealistic form of unity, we shall one day find ourselves represented by ill-qualified organizations more in the form of labor unions, veering away from the visionary objectives of true unity which the majority of the profession is seeking.

The AEA plan is purposely not presented with complete details of operation. It should not be proposed that the plan be accepted without thorough investigation but rather that its possibilities be studied in all its ramifications to the end that if the plan has merit, a workable proposal for a unity organization be evolved in a form acceptable to all of the societies.

Despite the tragic apathy among a large segment of engineers in matters other than technical, there are many professionally minded engineers who look forward hopefully to the ultimate ideal situation where engineers are recognized by employers and the public as professional people, and every practicing engineer is registered to protect the public and the engineer, which will help to effect this recognition. This situation may come about in time but progress is slow. We need a unity organization *now* and to obtain it we must all sacrifice some ideals of perfection and face reality. Until we have completely sold the public, the employers of engineers, and members of our own profession on registration and professional recognition, we cannot effect a true unity organization if registration is a *must* requirement of membership in such an organization.

The AEA Plan for unity, its proponents feel, might become a major step toward the ultimate goal, though admittedly not approaching perfection in a unified profession. It has been suggested that we take the first step now by unifying what we have today through adoption of the AEA Plan. We can then, through this initial unity organization, continually and agressively work toward the ideal of having universal registration of all professional engineers, and the instilled awareness of the need for registration among all engineers, which will give us a truly "professional" profession based on public recognition and deep, sincere, professional consciousness among engineers.

Progress toward any plan of unification can be stimulated if each of us, as an individual, will endeavor to preach and act professionalism, and will recognize at all times our responsibilities to the public and to our profession. If we are to have a strong unified profession, the individual must be conscious of his obligations and work actively toward the ultimate goal of true professionalism, thereby earning complete public recognition of engineering as a profession.

The AEA plan, as described in this article, has been presented to the Planning Committee of Engineers Joint Council for its consideration.

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The Shippingport Atomic Power Plant

P. A. FLEGER

With the ground breaking for the first full-scale nuclear-energy plant for producing electric power, a project was started which in a few years will provide invaluable information on many phases of construction, operation, manpower, and costs.

ON SEPTEMBER 6, 1954, President Eisenhower passed a baton containing neutrons over a block of uranium in Denver, Colo. With the speed of light a fissionable reaction swept 1,200 miles over the prairies to a picturesque site on the Ohio River near Pittsburgh, Pa. There, in the presence of Congressman Sterling Cole, co-author of the Atomic Energy Act of 1954, Admiral Lewis L. Strauss, Chairman of the Atomic Energy Commission (AEC), and some 1,400 persons, a giant tractor, with no operator at the controls, responded to the President's remote impulse. The tractor moved forward, scooped up a shovelful of earth, and the spectators, sensing the far-reaching significance of the occasion, rose and let out a tremendous cheer.

Thus, ground was broken for America's first full-scale nuclear power plant. Thus, on the outskirts of a tiny town called Shippingport, near the site of Fort Duquesne, an outpost of freedom for the early pioneers, was launched a great venture, one which may be destined to mark an historic turning point in the history of the electric power industry, of the United States, and, indeed, of the world.

Congressman Cole said: "Now we are at the end of the beginning. Now we translate our hopes and dreams of using the atom for the pursuits of peace into the concrete and steel of a plant producing large amounts of electricity."

Chairman Strauss described the project as "more fundamentally a pioneer venture than the first railroad to penetrate the west or the first airline to span the continent." "This ground-breaking," he said, "will surely project its effects into the remotest future for, as we turn the sod for this great new enterprise of the peaceable atom, we are also breaking ground in the area of international friendship and co-operation."

The story of Shippingport is everyone's story. In a sense this first full-scale atomic power plant is everyone's property. Although the plant will be jointly owned by the Government and the Duquesne Light Company, everyone will own the knowledge that is gained from it. Everyone will share in the dividends of the answers to the problems to be solved.

Shippingport is the result of an important decision, namely, that the development of nuclear power should be advanced from the laboratory stage to that of full-scale construction and operation. Some competent scientists and engineers believed that a full-scale nuclear power plant should be built only after it was more nearly certain the power it produced would be competitive with power produced from conventional fuels. But, as Thomas E. Murray, speaking for the AEC said when he announced the decision to construct this country's first full-scale nuclear plant, "Such a course meant more paper studies and more delays." He added, "We were persuaded that we had much to learn that could only be learned by building and by operating."

PRESSURIZED WATER REACTOR

THE REACTOR IN THE SHIPPINGPORT PLANT will be of the pressurized-water type. When construction of the plant was first proposed there was a natural and desirable difference of opinion as to the relative merits of this type of reactor and certain other types, principally the sodium-graphite, boiling-water, homogeneous, and fast-breeder reactors. The selection of the pressurized-water reactor for the first full-scale plant was largely governed by two factors: first, it was the only type of reactor then ready for full-scale construction; and, second it was the consensus of opinion that the development of all types of reactors would benefit from the information and experience that would be gained in the construction and operation of any full-scale plant, including the pressurized-water reactor. These considerations were emphasized in the initial report of the Joint Committee on Atomic Energy on the Five Year Power Reactor Development Program proposed by the AEC in February of 1954.

Hence, the Shippingport plant is not being built solely for the purpose of developing the pressurized-water reactor; rather, it is being constructed for the purpose of advancing nuclear-power technology generally. Accordingly, the entire plant is being built along very flexible lines. The reactor portion will accommodate additional cores of different types and larger size. Multiple components are being made by a number of manufacturers using different designs. And materials of various kinds are being utilized.

Of course, such flexibility will substantially increase the cost of Shippingport. But the larger investment is fully justified by the additional knowledge that will be gained. Knowledge, after all, is the immediate objective, for there is much to learn before it will be known how to build nu-

An address before the twenty-third annual convention of the Edison Electric Institute, Los Angeles, Calif., June 15, 1955.

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clear power plants that are competitive with conventional plants.

NO FIRM BASIS FOR COST ESTIMATES

From time to time estimates of the cost of power at Shippingport have been mentioned in newspaper and magazine articles and in radio and television programs. None of these estimates is authoritative and there is no firm basis for them. On the contrary, as the AEC pointed out when it first announced the project, one of the primary purposes of building the Shippingport plant is to provide a firm basis for estimating costs.

In developmental plants such as Shippingport, construction costs will reflect the cost of many things which have been embodied in the plant for research and development. The relatively high cost of components manufactured on a tailor-made or nontooled basis will also be a distorting factor. True construction cost values will be further obscured by subsidies from companies desiring to be associated with the projects for the purpose of gaining knowledge and prestige. Initial operating expenses will be inflated by manpower costs which will reflect lack of experience, insufficient knowledge of safety requirements, and test work. And, of course, initial operating expenses will also include charges for depreciation based on estimated lives which may or may not prove to be realistic in the light of experience.

Therefore the actual cost of electricity produced by developmental plants such as Shippingport will be of no significance whatsoever. On the other hand, with the knowledge gained from the construction and operation of these plants, it will be possible to estimate the cost of constructing and operating plants of the same type on a nondevelopmental basis and, from this, the cost at which such plants can produce electricity. These estimates will present some difficult questions, especially as to the life of various elements in the reactor portion of the plant and the proper amount to set aside each year for their depreciation. But reasonable accuracy should be attainable after several years' operating experience. Any estimates made prior to this will have to be based upon many arbitrary assumptions and will be in the nature of guesswork.

The beginning of test operations at Shippingport was originally scheduled for mid-1957. That is still the target date, but manifestly for such a revolutionary plant the schedule is a tight one. Excavation has been completed and large-scale construction is about to get underway.

The nuclear part of the plant is being designed and constructed by the Westinghouse Electric Corporation under contract with the AEC. Duquesne Light Company is building the turbine-generator portion and will operate the entire plant as an integral part of its system.

DESCRIPTION OF REACTOR

In the reactor a light-water coolant, under pressure, will serve both to slow down the high-energy neutrons and to remove the heat generated in the reactor core. The coolant will then pass to heat exchangers where the heat will be transferred to boiling water with the generation of steam. The steam subsequently will pass to a condensing turbine and then be returned through a regenerative cycle to the heat-exchanger boilers.

The reactor is expected to be inherently stable, which means that a rising temperature will reduce the reactivity and tend to reduce the heat output. However, the reactor will be provided with control rods which will be required for certain purposes. The reactor and boilers will be enclosed in large cylindrical steel containers to prevent the escape of radioactive material in the remote case of coolant-system failure.

The average temperature of the primary plant water will be maintained at about 525 F. The steam pressure at the turbine at full load will be about 600 pounds without superheat.

The entire plant, including the reactor, is being designed to meet the inherent requirements of the Duquesne Light Company's system as to rates of load pickup and rejection. The over-all control of the plant will feature ease and simplicity as necessities for safety and dependability. A single control room is planned in which the operation of the reactor, the turbine-generator, and the electric equipment will be concentrated.

The reactor will produce at least 60,000 kw net electric output. The turbine-generator will have a maximum capability of 100,000 kw.

VALUABLE INFORMATION WILL BE GAINED

At this early stage it is not possible to foresee all of the information that will be gained from the construction and operation of the Shippingport plant. Even the matters on which it is now known that valuable knowledge will be developed are too numerous to mention; it is only feasible to give a few examples.

With respect to the development of the pressurized-water type of reactor, the Shippingport plant will provide valuable information on pumps, primary circuit piping, heat exchangers, and other things peculiar to that type of reactor. This first full-scale plant to supply information of importance for almost any type of reactor capable of producing heat for the generation of steam for electric power.

As to heterogeneous reactors, that is, reactors with a core composed of different materials separated one from the other, Shippingport will help to determine the design methods of fabrication, life, and cost of fuel elements. Of great importance will be the experience to be gained with respect to the ability of different fuel elements to withstand long periods of irradiation and use. Also the effect of fuel element failures on the problems of maintenance and replacement of parts of the system other than the core will be learned.

For both heterogeneous reactors and homogeneous reactors, meaning by the latter reactors with a core composed of a uniform material such as a solution or slurry, the Shippingport plant will provide a fund of information. To mention just two things, information will be obtained on radiation levels and maintenance of radioactive equipment. Knowledge will be gained concerning the control problem, which embraces not only the need for dependable instruments but also information on the actual inherent behavior of the reactor. This involves changes in core reactivity,

both short-time and as affected by aging, which must be co-ordinated with the load changes arising in the particular system of which the plant is a part. Operating experience will develop practices for dependable service and for safety, which may eventually permit the elimination of much costly special construction. Although proper design and well-planned operation should minimize unexpected outages, valuable information will be gained from experience with emergency problems, such as scram, loss of auxiliary power, loss of coolant flow, and other mechanical and electrical failures. Operation of the Shippingport plant will also aid in determining the manpower requirements of nuclear power plants. This is especially important since a serious problem lies in the shortage of well-trained experienced scientific and engineering personnel. A preliminary manpower schedule for Shippingport has been established and training of the personnel will be started very soon, or about 2 years before initial test operations are to begin.

Consistent with the developmental character of the Shippingport project, the AEC is sponsoring a comprehensive educational program in conjunction with the design, construction, and operation of the plant. The program will include periodic information meetings, plant tours, and progress reports. To facilitate this program the AEC is declassifying information concerning the project as rapidly as security requirements will permit.

Thus, Shippingport will be a university, so to speak, for the electric-power industry of the United States, for the free nations of the world and, within the limitations of national policy, for the countries behind the Iron Curtain as well.

At the ground-breaking, Chairman Strauss declared: "Men of many friendly nations in the days to come will be welcomed to this place where we are now standing—to study, to observe, and to carry home with them the benefits of our technology, devoted solely to the arts of peace."

AEC PHILOSOPHY

In outlining the basic philosophy of its civilian reactor program, the AEC recently said that, "The Commission's role should be to develop advanced technology at government expense and to stimulate outside groups to undertake developmental or demonstration power projects primarily with non Commission financing." The AEC also said that "developing economically competitive nuclear power for civilian use will be aided by maximum practical utilization of the financial incentive common to business ventures."

The Shippingport project is a concrete expression of this philosophy. It will develop advanced technology at Government expense. It has already served to stimulate other groups to undertake developmental or demonstration power projects; in fact, one might say that the initiation of the Shippingport project "broke the ice" as far as construction of full-scale plants is concerned. As to the utilization of financial incentive common to business ventures, Shippingport is a natural and logical step in an orderly transition from the complete Government monopoly produced by the military requirements of World War II to the development of the atom for industrial purposes by private business under the regulatory supervision of the Government. The partnership engaged in this transitional project capitalizes on the broad knowledge gained by the Government in the development of atomic weapons, as well as the Government's extensive resources; it takes advantage of the experience of one of the foremost industrial organizations in the nuclear-power reactor field; and it recognizes that, since nuclear-power reactors must be so constructed that they will be able to meet the inherent requirements of the particular electric-utility system which they serve, the knowledge and experience of an electric-utility operating company is essential, too, in designing and building reactors.

A CHALLENGE AND OPPORTUNITY

With the dropping of the atomic bomb on Hiroshima and Nagasaki, the scientists opened up a Pandora's Box of the energy that lights the stars. As a result, the electric-utility industry is presented with a tremendous challenge and, at the same time, with a tremendous opportunity.

In the quest to make this new fuel competitive with fossil fuels, and thereby to take advantage of this inexhaustible supply of new energy, there is not only a duty to perform, entailing the risk of capital as it will, but it also offers self-protection to the electric-utility industry. In May the AEC said, "The early development of economically competitive nuclear power by the United States is an important national objective." The AEC we on ntto say that, "Achieving economically competitive nuclear power in an accelerated time schedule is believed to be desirable, if not essential, for both domestic and international reasons."

In other words, the Government is committed to developing nuclear power as rapidly as possible, and if private industry does not undertake this development the Government is prepared to do so. This, of course, could sound the death knell of investor-owned electric-utility industry. There is no doubt that the electric industry is alert to its responsibility, its challenge, and its opportunity.

This generation has seen commercial aviation develop to the point where men of action cross the continent in 8 hours, cross the Atlantic in slightly more time; and they board planes for the Orient with the facility with which one takes a bus to go to and from downtown. People sit in their homes and listen to radio broadcasts from Tokyo, London, Berlin, and Rome; and view television spectacles in distant places.

Yet the advance of the electric-power industry since that first day at the Pearl Street plant in 1882 has been equally impressive. It has relieved the drudgery of millions of housewives. It has straightened the backs of countless farmers and industrial workers, and it has increased their productivity many many times.

In spite of periodical material shortages the electric-power industry has kept abreast of the nation's increasing thirst for power as the years have rolled by. It has played an indispensable part in making the United States the most powerful in the world. Very definitely it has stamped its imprint on America's profile. There is not the slightest doubt it will make its due contribution to the atomic age. The Shippingport atomic power plant is a part, a necessary part, of that contribution.

Power-Class Recloser for High-Speed Circuit Clearing

E. J. FIELD
MEMBER AIEE

D. L. LEATHERBERRY

CONDUCTOR BURNDOWN, one of the distribution engineer's major problems, focuses attention upon a need for higher speed interrupters. Automatic circuit reclosers with present "instantaneous" or "fast" time curves meet this need only partially because as much as 48 cycles is required to clear the circuit. A new design provides circuit clearing in one to three cycles, depending upon fault-current magnitude. It also provides 20-cycle reclosing for quick circuit pickup following clearing of a transient fault.

Development of a power-class recloser capable of clearing a 15.5-kv circuit of a 5,600-ampere fault, one cycle after inception of the fault, involved some unusual problems. An objective of 1-cycle circuit interruption makes high-velocity contact separation mandatory. A high initial force necessary to accelerate parting contacts conflicts with a low terminating force required at end of contact travel. Limitation of high fault current arcing to one-half cycle demands an unusually efficient interrupter. Furthermore, the interrupter design must permit almost instantaneous restoration of normal conditions following interruption in order to accommodate quick reclose and be ready for an immediate subsequent interruption. In addition, the mechanical design must accommodate high momentary stresses and yet be sufficiently compact to confine physical size to an acceptable limit. Designs that solved these problems yielded interesting and effective results.

For the interrupter unit, a single contact construction was proposed to embrace the desirable elements of minimum moving mass, minimum arc energy, the least hydraulic friction, and simplified construction. The design evolved employs a new principle in arc extinction called an "oil-column interrupter." Basically, it is a column of oil bounded by the inside walls of a hollow moving contact. In operation, the contact moves off of the stationary column of oil, progressively exposing new clean oil to the area of the moving contact on which the arc terminates, being very effective.

The contacts are separated by electromagnetic means with provision for cancelling the driving force towards the end of contact travel without affecting the maximum accelerating force necessary at the start of contact travel. Armature construction permits introduction of a sharp cut-off point in the electromagnetic force at a predetermined point in contact travel.

A major problem encountered in the prototype was an accelerating thrust imposed upon the end of the moving contact by the pressure developed within the interrupting chamber. The problem was solved by incorporating a double-section internal cavity. This construction allows hydraulic pressure to be transmitted through the insulating fluid and to act vertically downward upon a pressure shelf in opposition to the pressure imposed upon the end of the moving contact.

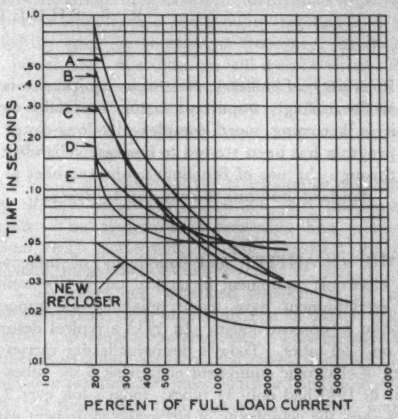

Fig. 1. Comparison of new "instantaneous" curve with other known "instantaneous" or "fast" recloser time curves: a, b, c, d, e

Following circuit interruption, the moving contact structure must be brought to rest with minimum mechanical stress. This is accomplished in a decelerating cavity with tapered side walls. Utilizing known mass, a known velocity established by test, and an assigned maximum fluid pressure, the taper was calculated to provide uniform deceleration, utilizing the annular space between cavity wall and flange armature as a variable orifice.

Adoption of the outlined design concepts yields a compact automatic circuit recloser having the "instantaneous" time–current curve identified as "new recloser" in Fig. 1.

Seventy per cent of the range of interrupting capacity is accommodated by 1-cycle circuit clearing. Even at minimum operating current, circuit clearing is accomplished in three cycles after initiation of the fault. Comprehensive tests disclose that this high-speed performance functions over a voltage range at least from 2,500 volts to 15,000 volts for continuous current ratings from 100 amperes to 280 amperes, inclusive. The short arcing time and low arc energy that are characteristic of the oil-column interrupter result in negligible contact erosion, and thus contribute to an extended useful life of the apparatus. The higher speed recloser provides the distribution engineer with an effective means of coping with faults occurring on his distribution power circuits.

Digest of paper 55-510, "A Power-Class Recloser for Higher Speed Clearing of Distribution Circuits," approved by the AIEE Committee on Switchgear and recommended by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 27–July 1, 1955. Scheduled for publication in AIEE *Power Systems and Apparatus*, 1955.

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Standard Functional Divisions for Electronic Equipment

R. S. SHULTZ W. R. WALTZ

Reliability of military electronic equipment is an increasingly important factor, especially as it is becoming more complex. A long-range program has been started to increase reliability through the use of functional subassemblies as standard building blocks for equipment.

THE QUANTITY and complexity of present-day electronic equipment in tactical use by the military establishment have made reliability an important factor in equipment design. In 1937 a typical destroyer had only 60 tubes. Today's destroyer leader carries 772 pieces of electronic equipment employing 6,585 tubes. A radar in 1940 had only 44 tubes; today's has over 2,000 tubes—and the complexity of electronic equipment varies, roughly, as the square of the number of tubes! It has been estimated conservatively that the complexity of military electronic equipment will at least double in the next 5 years. In the face of this increasing complexity, it is mandatory that only proven components and designs be used if even the present level of reliability is to be maintained. This article describes the first phases in a long-range program to achieve increased reliability through the use of functional subassemblies as standard building blocks for electronic equipment.

The concept of standard building blocks offers many advantages. Increased reliability, resulting from the use of selected or preferred circuitry, is one of the more important advantages. Another is the rapid fault location and replacement of assemblies, rather than parts, thus reducing the "down time" in equipment failures. Other important benefits include: use of less technically trained maintenance personnel; increased possibility of incorporating automatic fault-locating devices in equipments; reduction of spare-parts stores due to interchangeability of building blocks from equipment to equipment; economic gains in procurement, storage, and distribution; reduction in engineering time and manpower in new equipment development; and use of mechanized production techniques.

The Vitro Laboratories, under contract with the Bureau of Ships, is conducting the first phases in the program of standardization. The objective is the determination and recommendation of functional divisions of electronic equipment suitable for standardization. As a basis for determining these divisions, a survey of almost 100 equipments containing approximately 3,000 functional divisions has been made. These equipments selected as representative of Navy electronic equipment in current use include communications, radar (search and fire control), navigational aids, sonar, countermeasures, identification, infrared devices, and radiation detectors, as found in ship, shore, and airborne applications. These functional divisions are now being analyzed to determine electrical and mechanical characteristics. The functional divisions will then be grouped by their characteristics, and description sheets written for a series of divisions satisfying the range of equipment requirements. It is expected that these description sheets will be submitted to industry for development of prototype subassemblies, designed to take advantage of mechanized assembly techniques. Specifications for standard building blocks based on the description sheets, will be established only after testing and selecting the most reliable units.

Standard subassemblies, or building blocks, become components and are subject to improvement like any other component. Circuitry and physical composition are subject to change, depending on the state of the art. It is the functional requirements of the unit that remain fixed. As with any standardized component, only significant improvements in performance, weight, or size should influence any change in the specifications. Minor design modifications not affecting direct interchangeability may be permitted.

Two concepts of a functional division have been considered in the analysis. These may be called the "equipment-function," a unique group of circuits characterized by the equipment in which it is found, and the basic electrical function, such as amplification, waveshaping, frequency changing, and wave generation. Fig. 1 illustrates how a typical radar indicator may be separated into equipment functional divisions. The functional divisions based on equipment-function are:

1. Gate circuit
2. Video circuit
3. Range sweep circuit
4. Height sweep circuit
5. Range marker circuit
6. Height line circuit
7. Intensity compensation circuit
8. Sector gating circuit
9. Servo amplifier

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10. Synchro system
11. Cathode ray tube and controls
12. Power supply

This is a simple breakdown in that only 12 divisions are in the entire equipment and would be satisfactory if only radar indicators were to be standardized. Eight of the 12 functions listed are applicable only to radar equipments, whereas basic electrical functions are common to practically all equipment types.

The same radar indicator further divided into the basic electrical functions is shown in Fig. 2. Note that the equipment-functions, with little or no similiarity between them, are now divided into twice as many electrical functions appearing in greater frequency. It is the second approach, the basic electrical functional division, that has been adopted for this program. While this may possibly mean over-fragmentization in some instances, it is more practical to recombine some functional divisions into working subassemblies than it would be to redivide some of the larger ones.

An example of this is the "front end" of communications receivers. The method of breakdown now in use calls for separating the r-f amplifier, the local oscillator, and the mixer into individual functions. This is desirable because each of these functions is found in other equipment types. However, when it comes to standardizing these functions for receivers, tuning and tracking requirements make it necessary that these functions be recombined and treated as a unit.

The analysis consists of separating the equipment into specific functional divisions and determining electrical and mechanical characteristics for each division. These divisions are then grouped by function, irrespective of the parent equipment. The characteristics of each division within the function group are then tabulated in order to form families of parameters satisfying the general requirements of the group. For example: all divisions whose basic function is amplification are grouped together and subdivided by such parameters as frequency, bandwidth, gain, power, etc. Specifications will then be written for a series of standard amplifier building blocks based on the afore-mentioned families of parameters. These relatively few amplifier building blocks should meet most requirements for this function.

In practice, the analysis involves a thorough engineering study of the equipment instruction and maintenance manuals. The equipment is separated into functional divisions, each performing a basic electrical function. In general, these functions are not complex, and comprise only a few tubes and associated components. A more detailed analysis is made of each division for data describing the input and output characteristics. This includes such parameters as amplitude, dynamic range, impedance, frequency or repetition rate, pulse width or bandwidth, waveshape, rise time, phase shift, power requirements, number of inputs and outputs, approximate weight and volume, and mechanical features. It is thus possible to describe the requirements of a functional division without specifying circuitry or hardware. For example: an amplifier function can be described without any reference to its circuitry

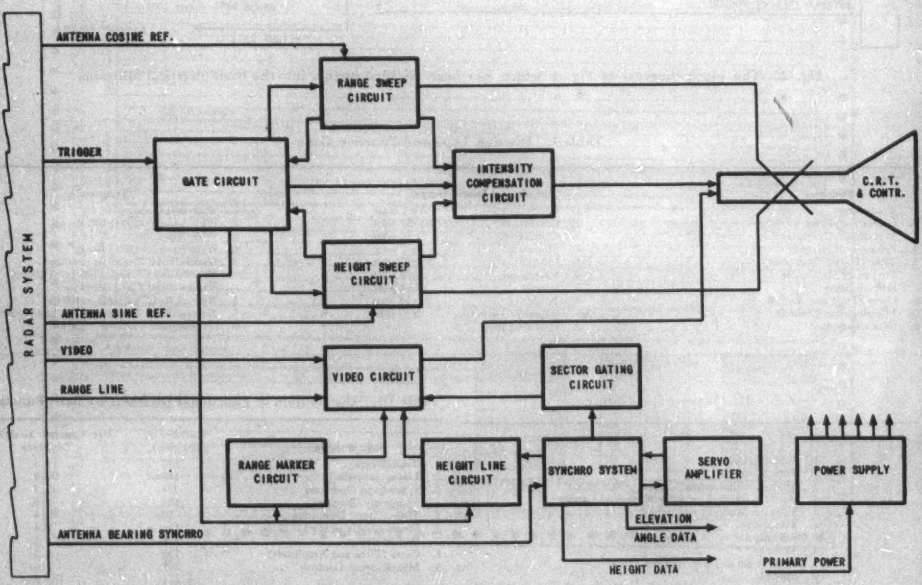

Fig. 1. A block diagram of a typical radar set which has been separated into functional divisions

which may be satisfied by conventional vacuum tubes, transistors, magnetic devices, or some other means not yet developed.

Information obtained from the analysis is recorded on McBee Keysort cards. Figs. 3 and 4 show a functional division analysis card. By proper coding, the desired information can be punched around the edges of the card and the cards can be sorted by function or by parameters. The basic information for grouping the analysis cards by similar functions is contained in a 3-digit function code and a single-digit waveform code. Since both input and output waveforms are used, the resultant sorting and grouping tool is a 5-digit code.

Tables I and II show division type and function code, and

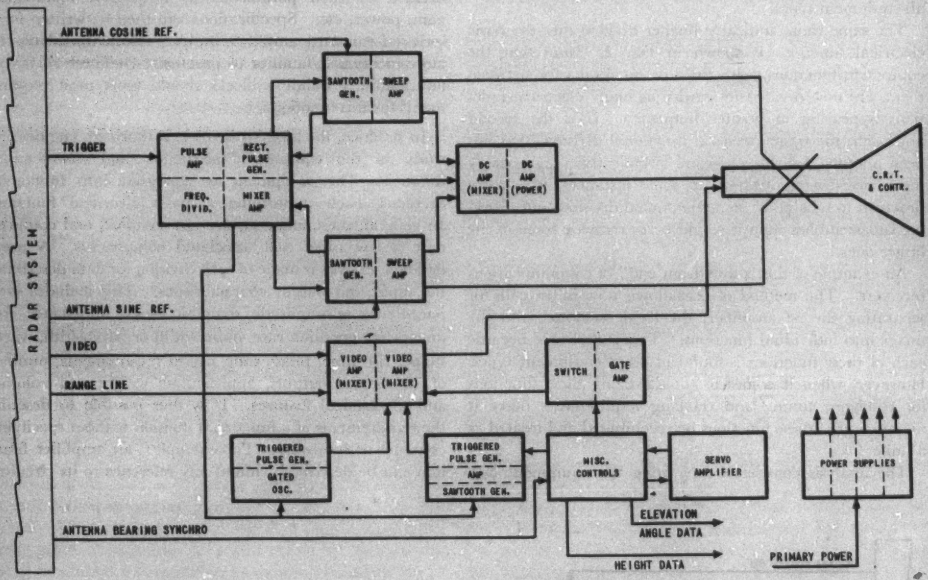

Fig. 2. The block diagram of Fig. 1 which has been divided further into the basic electrical functions

Table I. Division Type and Function Code

Function	Mode and Power Output		Frequency
1. Transducers	1. Continuous	To 1 watt	1. Wide Band: dc to 100 kc
2. Linear Amplifiers	2. Continuous	>1–50 watt	2. Wide band: dc to >100 kc
3. Waveshape Operators	3. Continuous	>50 watt	3. Wide Band: ac to 100 kc
4. Frequency Changes	4. Modulated	To 1 watt	4. Wide Band: ac to >100 kc
5. Time (Phase) Operators	5. Modulated	>1–50 watt	5. Narrow Band Fixed: dc to 100 kc
6. Frequency Generators	6. Modulated	>50 watt	6. Narrow Band Fixed >100 kc to 100 mc
7. Demodulators	7. Pulsed	To 1 watt	7. Narrow Band Fixed >100 mc
8. Gates (Time and Amplitude)	8. Pulsed	>1–50 watt	8. Narrow Band Variable to 100 kc
9. Miscellaneous Controls	9. Pulsed	>50 watt	9. Narrow Band Variable >100 kc to 100 mc
0. (Not assigned)	0. (Not assigned)		0. Narrow Band Variable >100 mc

Table II. Waveshape Coding

1.	Variable DC
2.	Pure Sinusoid
3.	Modulated Sinusoidal Carrier (AM or FM)
4.	Bursts of Single-Frequency Sinusoidal Carrier
5.	Voice or Music
6.	Triangular
7.	Rectangular
8.	Transient
9.	Pulse Train or Pulse Indexed Signal
0.	Special

Table III. Distribution of Functional Divisions by Basic Function

Basic Function	Number of Divisions	Per Cent of Analyzed Divisions
1. Transducers	223	10.6
2. Linear Amplifiers	648	30.9
3. Waveshape Operators	334	15.9
4. Frequency Changers	136	6.5
5. Time (Phase) Operators	72	3.4
6. Frequency Generators	176	8.4
7. Demodulators	178	8.5
8. Gates (Time and Amplitude)	130	6.2
9. Miscellaneous Controls	202	9.6
	2,099	100.0

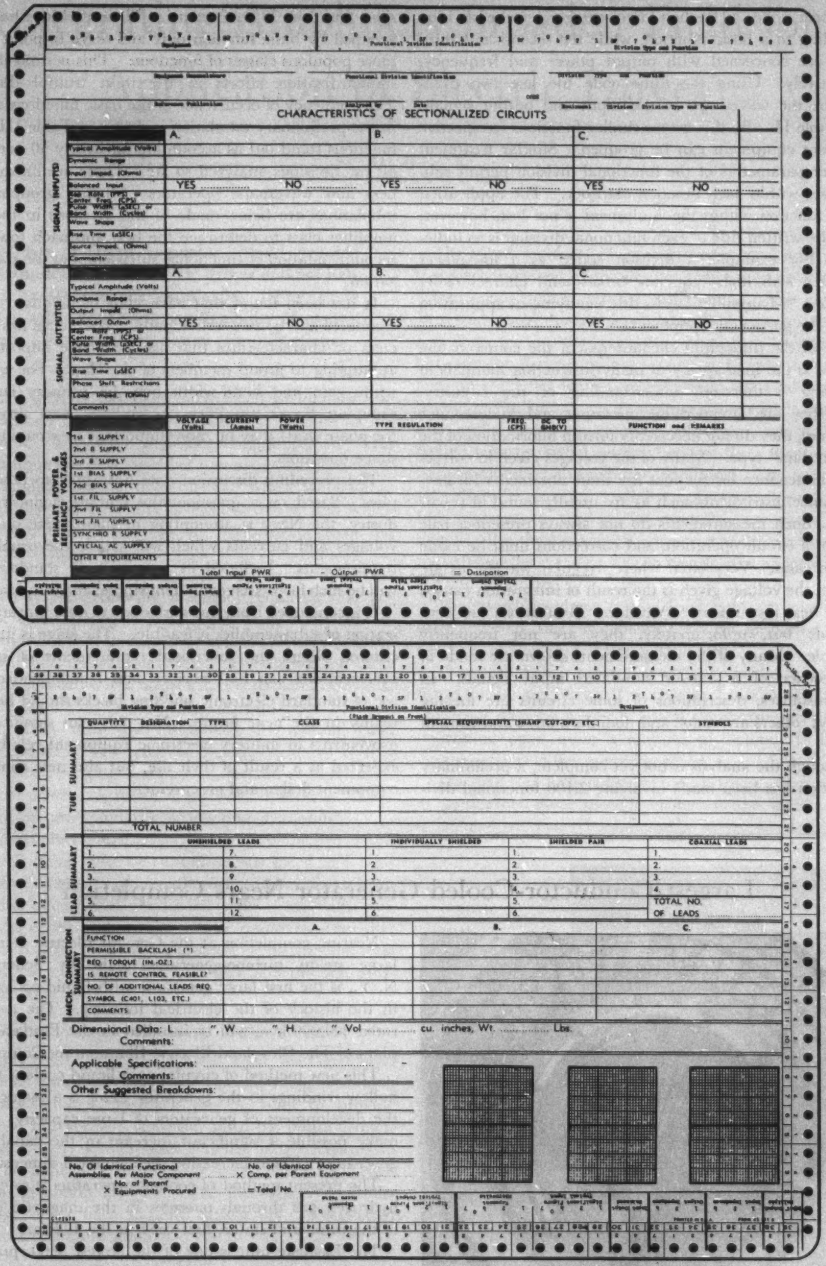
CHARACTERISTICS OF SECTIONALIZED CIRCUITS
SIGNAL INPUTS
SIGNAL OUTPUTS
PRIMARY POWER & REFERENCE VOLTAGES
TUBE SUMMARY
LEAD SUMMARY
MAJOR CONNECTION SUMMARY
Dimensional Data: L ..... ", W ..... ", H ..... ", Vol ..... cu. inches, Wt. ..... Lbs.
Comments:
Applicable Specifications:
Other Suggested Breakdowns:

Fig. 3 (above) and Fig. 4 (below). Front and reverse of the analysis card used in the study of equipment

waveform code. The first digit categorizes the division according to a basic function, while the second and third digits are concerned with output power and frequency, respectively. Using the same code the last two digits describe the waveshape of the input and output signals. See Table II. By this means similar functions irrespective of parent equipment can be grouped. Similar treatment of other parameters of the functional division permit subgrouping within each function category. The application of the function within the equipment is not lost, however, since the written title of each functional division is so indicative. For example, a division coded as a low-power amplifier with high-frequency broad-band characteristics may have "i-f amplifier" as its title signifying its application within the particular equipment.

One of the difficulties encountered in the course of the analysis is the inadequacy of many instruction manuals in providing a thorough understanding of the circuitry. Since they are intended for operating and maintenance personnel, they do not necessarily furnish information of the "design data" type. Many of the voltages given in corrective maintenance instructions are those obtained with low-impedance instruments such as are usually found in repair shops. Such measurements do not always present a true picture of circuit operation, and corrections must be made in such cases. Very often where irregular waveforms are present, the voltage given is the result of integration caused by the test instrument. Waveform illustrations aid considerably but, unfortunately, they are not frequently available. Many of the measurements shown are made in the absence of actual or simulated input signals. In some instances, descriptions of some circuits are missing entirely; others are vague and noninformative and contain errors.

Although the analysis is not yet complete, a preliminary tabulation has been made involving 2,100 functional divisions found in 75 equipments. These divisions have been grouped by basic function only and serve to point out the more populous classes of functions. This permits directing standardization efforts in the most fruitful directions. The frequency of occurrence of the basic functions as found in the preliminary tabulation is shown in Table III. Two functions stand out as accounting for nearly 50 per cent of all the divisions analyzed so far. These are linear amplifiers and waveshape operators. Further groupings and tabulations are being made of the divisions in the linear amplifier class to determine the best approach toward the recommendation of functional subassemblies for standardization.

It has been found that each class of function must be examined and treated individually. Each class has parameters or characteristics that assume prime importance in attempting to group members of the class. For example: while gain and band-width may be primary factors in grouping linear amplifiers, waveshape and time delay (or phase shift) may be more important in grouping waveshape operators.

The preceding discussion does not apply to power supplies. Based on a questionnaire sent to engineers in industry, the Navy is attempting to standardize on several voltages and currents which will satisfy the usual power requirements. Included in power-supply standardization will be such factors as regulation, ripple, and duty cycle.

It is concluded from the work done to date that standardization of subassemblies is feasible. The stage is just being entered where the functional requirements of standard subassemblies can be described and recommended. The use of standard electronic building blocks should become a reality in the near future. Not only can significant improvements in military electronic equipment reliability be expected as a result of their use, but also new concepts in equipment design and procurement.

Largest Conductor-Cooled Generator Nears Completion

Nearing completion at the General Electric Company's large steam turbine-generator plant in Schenectady, N. Y., is the first large generator with liquid-cooled stator in the history of the electrical industry. The new unit, rated 260,000 kva, will be installed in the Eastlake power plant of The Cleveland Electric Illuminating Company.

This new method of circulating a liquid coolant through hollow windings in the generator stator is a major step in the development of generators of large capacity. It will make possible a significant increase in the capability of generators without increasing their physical dimensions.

The present method of cooling generators is to circulate hydrogen gas through passages in the magnetic portions of the rotor and stator, first used in the 1920's.

The Eastlake unit is one of the largest 3600-rpm steam turbine-generators in the world. Three conventional hydrogen-cooled turbine-generators, each rated 125,000 kw, are already in operation at this station.

Integrating Amplifiers Broaden Field for Application of Electric Drives

C. D. BECK
ASSOCIATE MEMBER AIEE

This type of speed regulator should provide new applications for electric drives and set new machine-performance standards. Often these drives will provide greater flexibility of control and allow machine-design simplifications.

A NEW TOOL has been introduced to increase the accuracy of the speed regulator by as much as 100 times. This is the new integrating amplifier. This new technique was developed because many special new industrial applications had been foreseen which will require the reliability and flexibility of electric drives, and which will demand even more exacting performance than has been required in the past.

In the paper industry, these new applications will be mainly for paper processing machines requiring that adjacent or co-ordinated sections break away from rest together, and that they operate over essentially infinite speed ranges without measurable error. The drives for these applications must be free of drift and capable of operating with wide readily adjustable differences in speed between sections. They must also be capable of holding good absolute speed. They must be flexible systems, readily adaptable to changing machine or process requirements. They must be simple, reliable, and easy to service. They must provide new standards for machine availability.

With these objectives in mind, the merits of the two fundamental regulating systems—instantaneous speed and position—were studied and evaluated. Laboratory tests, duplicating actual field conditions, were made with both systems, to check performance. The results indicate that the speed regulator offers the greatest flexibility, the least electrical and mechanical complication, and the best overall performance.

COMPARISON OF THE TWO BASIC SYSTEMS

POSITION REGULATORS will hold good average speed over wide operating ranges. Special designs which have rate-of-change feedback can be built to provide good speed of response; however, since the position regulators are usually synchronous systems, it is necessary to provide an adjustable mechanical speed changer for each regulator to obtain DRAW. The mechanical transmissions have never been entirely satisfactory. They often limit the field of application.

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The speed regulator likewise provides good steady-state speed accuracy and eliminates the need for adjustable ratio transmissions (cone pulleys), differentials, and clutches. In recent years, the speed regulator found greater application than the position regulator, because it is inherently fast, and for that reason has set new standards of performance on machines which are subject to fast load changes. Auxiliary functions such as starting, slow speed, acceleration, and stopping are simplified and more accurately controlled with the speed system, because these functions can be accomplished through the regulator. The speed system also offers greater flexibility because additional variables (current or tension, for example), are easily introduced. For these reasons it appears that the speed regulator will find the greater usage on new special applications in the paper industry.

The speed regulator has a finite gain or steady-state accuracy, and, since it depends upon d-c amplifiers for its salient characteristics, it is subject to drift.

The speed drift is caused by a change in the characteristics of the d-c amplifier. This change occurs slowly, usually requiring days or weeks to reach significant proportions, depending upon quite a number of factors. It has its greatest effects at low operating speed.

The drift is of little consequence on drives which operate at essentially a given speed level, because the operator auto-

Fig. 1. Industrial design integrating amplifier for use in a high-accuracy speed - regulating system

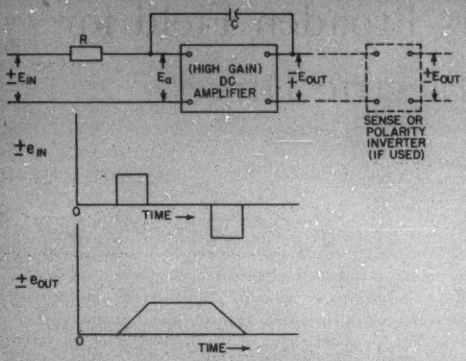


Fig. 2. Electronic integrator with an example of input and output

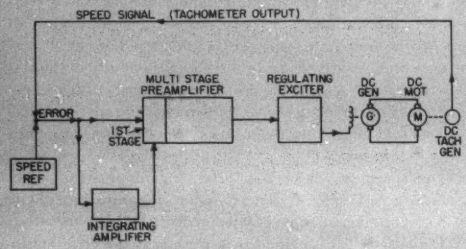


Fig. 3. High-accuracy speed regulator

matically compensates for it when making routine speed adjustments dictated by the process. Actual operating experience has shown that these systems are capable of maintaining absolute speed within 0.1 per cent for a matter of days between adjustments, so that the drifts concerned are actually quite small. Also, a major portion of this 0.1-per-cent drift is caused by the reference, which does not affect the differential speed between sections on a co-ordinated drive. The changes in the reference, which affect absolute speed, are common to either the speed or the position regulating systems.

The significant fact is that the amplifier drift represents a constant deviation from the set point regardless of the operating level, and thus becomes increasingly important on drives which require high steady-state accuracy at low operating speeds.

THE INTEGRATING AMPLIFER

THE NEW INTEGRATING AMPLIFIER has been introduced to offset the effects of amplifier drift and to increase the accuracy of present speed regulators at low operating speeds. One standard industrial design of this new tool is shown in Fig. 1. It consists of a mechanical vibrating converter, an a-c amplifier, a phase-sensitive discriminator, and a sense or polarity inverter.

Schematically an electronic integrator may be represented by a resistor R, a capacitor C, and a high-gain amplifier, as shown in Fig. 2. It performs an integration by charging the capacitor through resistor R. First, visualize the input to the amplifier E_a connected to the grid of a vacuum tube, so that it draws no current. Any current that flows through resistor R will then also flow through the capacitor. The function of the amplifier is to maintain the voltage E_a at zero volts, so that the current in resistor R (and capacitor C) will be directly proportional to the input voltage E_{in}.

If a voltage is applied at E_{in} the amplifier will integrate it with respect to time and give an output voltage E_{out} which is proportional to the product of E_{in} and time, as shown in Fig. 2. Therefore, it can be used to integrate a speed signal into a position signal.

Another point worthy of mention is that the integration takes place instantly. There is no time delay because of the RC time constant.

The integrating amplifier employs another circuit technique that essentially eliminates any drift in the amplifier. This is accomplished by using a-c amplifiers. The heart of this technique is the vibrator converter which changes the d-c input signal to the amplifier to alternating current. After the a-c signal is amplified, the vibrator converts it back to direct current. Since the a-c amplifiers are not affected by drift, they provide a simple method of eliminating this effect in conventional speed-regulating systems.

How the Integrating Amplifier Is Used. In some positioning applications, the new amplifier was used as an integrator to obtain a position signal by integrating a speed error from a d-c tachometer generator. The advantage of this technique was to eliminate the adjustable mechanical transmissions required with a synchronous type of position regulator.

In the paper industry, there is basically more interest in SPEED than in POSITION. Thus the integrating amplifier is used as a precision speed control rather than as an integrator to obtain position regulation.

The schematic diagram in Fig. 3 illustrates how the new amplifier functions in a high-accuracy speed regulating system. Any speed error—that is, the difference between the tachometer output and the reference—is applied to both the preamplifier and the integrating amplifier. The first has a limited gain, dictated by stability considerations, and provides extremely fast response, a characteristic of high-accuracy speed regulators. The integrating amplifier provides additional gain, approximately 100 times, which can be utilized because of the delay or rate action of the integrator.

The higher the gain of the system, the closer the tachometer generator voltage can be matched to the reference. Thus it is quite apparent that one effect of the new amplifier is to increase the speed-regulator accuracy by the amount of the integrating amplifier gain. Of greatest practical importance is the improvement in low-speed accuracy.

Another benefit is that it eliminates the effects of amplifier drift.

To illustrate, assume there is a Ward-Leonard drive with an inherent regulation of 10 per cent, an open loop gain of

400 through the d-c amplifier, and a gain of 100 in the integrating amplifier. The steady-state regulation is than reduced to 10/400 × 100 or 0.00025 per cent. Likewise, if in a matter of days or weeks the pre-amplifier should drift by 0.2 per cent, the integrating amplifier will reduce this to 0.002 per cent. On a 5,000-feet-per-minute machine this is $^1/_{10}$ of 1 foot per minute at top speed, which is more accurate than can be set by an operator.

Other Accuracy Considerations. The performance of the new speed regulator is so good for both transient and steady-state conditions that accuracy limits must be sought elsewhere. The limits are now set by the quality of the reference and the feedback. Standard available references for a speed-regulating system are accurate to ± 0.05 per cent. The d-c tachometers which are occasionally used as the reference, and always used for the feedback, are actually guaranteed for a drift of less than 0.03 per cent for an 8-hour period. The temperature coefficient is approximately ± 0.0012 per cent per degree C.

Actually, it is becoming clear that the control is no longer the element that limits the accuracy of present-day speed-regulating systems. The present barrier to faster response and greater accuracy lies in the mechanical equipment. The major factors are roll unbalance and mechanical backlash in the gearing and couplings. On several recent drives, direct-connected low-speed motors were applied to reduce the mechanical backlash. The regulating performance showed remarkable improvement.

RECENT APPLICATIONS OF THE NEW SPEED REGULATOR

IT WILL BE OF INTEREST to mention two recent applications where the integrating amplifier made it possible for several co-ordinated Ward-Leonard drives to meet the exacting requirements of special paper-processing machines. The first is a calender-rewinder drive; the second, an off-machine coater.

Calender-Rewinder Drive. The machine arrangement and drive are shown schematically in Fig. 4. The function of the machine is to unwind two rolls of creped paper, stretch the paper a specified amount between each section, and rewind it into a number of 2-ply rolls for facial or toilet stock. It is roll-for-roll operation requiring frequent stops and starts. The rated speed is 5,000 feet per minute.

The essential requirements are to break all sections away from rest in exact correspondence, and maintain good differential speed accuracy during acceleration, deceleration, and steady-state running, over an infinite speed range. The rolls have such high inertias that drives of 50, 125, 125 and 75 hp are required, primarily for acceleration and deceleration.

Each motor is powered from a separate d-c generator. The entire speed range is obtained by armature voltage control. Direct-connected d-c motors are used to eliminate the effects of mechanical backlash. A conventional electronic-amplidyne regulator is used in combination with an integrating amplifier to regulate the speed of each individual section.

In actual operation the speed error between sections is about 0.01 per cent of top speed for steady running, and less than 0.1 per cent during acceleration and deceleration at rates of 100-feet-per-minute per second. Upon starting, the sections break out from rest in exact correspondence.

The new amplifier has another asset in the ease with which it can be reset electrically. If the operator jogs one section ahead of the other during the threading operation, this reset characteristic eliminates the need for mechanically repositioning the regulators on the drives to get them to start together.

This is a good example of a special new application for electric drives requiring high-accuracy regulators. The new integrating amplifier has made it possible to meet the exact regulating requirements, where it was felt that mechanical drives would not withstand the rigors of acceleration and deceleration, and where adjustable ratio transmission were undesirable because of the maintenance required in a dusty atmosphere.

Coater Drive. The roll-for-roll off-machine coater, shown schematically in Fig. 5, is another unique drive application requiring frequent acceleration and deceleration. The amount of coating applied to the sheet, from the puddles between rolls *R2* and *R3* and *L2* and *L3*, is accurately metered and leveled by controlling the nip and the speed of the individual rolls. Rated machine speed is 1,400 feet per minute. Thread speed is 50 feet per minute. Since it is an experimental machine, it has several unusual operating requirements.

For one requirement, the seven driven rolls may be set for

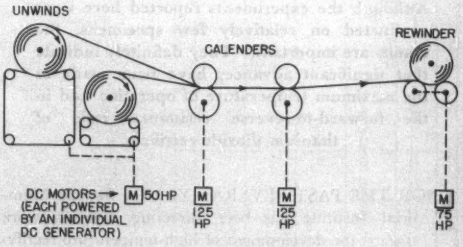


Fig. 4. Calender rewinder

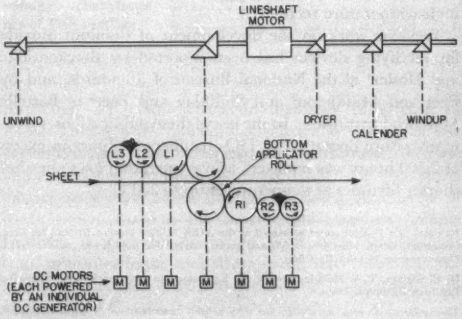


Fig. 5. Off machine coater

any speed between 30 per cent above or below machine speed. The rolls should maintain this speed differential regardless of machine speed, and should hold the set speed to within 0.06 per cent of top speed for a 100-per-cent change in load.

For another operating condition any one of these same seven drives, when held in speed by an adjacent roll, must regulate a set current, either motoring or generating over a 28-to-1 speed range. In this application, the new amplifier is used with a standard thyratron regulator. Again each motor is powered by its own generator, and either speed or current is regulated by armature voltage control. This is another example where the high-accuracy speed regulator enables the electric drives to set new standards of machine performance and flexibility.

CONCLUSION

THERE ARE MANY APPLICATIONS where this new speed regulator will open the way to new uses of electric drives and set new standards of machine performance. It also will be found that these drives will often provide greater flexibility of control and permit simplifications in machine design. Electric drives controlled by high-accuracy speed regulators will raise the present limits of speed and capacity on machines which are now limited by the power that it is practical to transmit mechanically.

High-Temperature Area-Type Titanium-Dioxide Rectifiers

H. C. GORTON T. S. SHILLIDAY F. K. EGGLESTON

Although the experiments reported here were conducted on relatively few specimens, the results are important. They definitely indicate that significant advances have been made in the maximum temperature of operation and in the forward-to-reverse resistance ratio of titanium dioxide rectifiers.

FOR THE PAST SEVERAL YEARS, Battelle Memorial Institute has been directing research work toward the development of high-temperature rectifying devices under sponsorship of the U. S. Air Force. Principal efforts during the past $2^1/_2$ years have been directed toward the development of titanium dioxide as a high-temperature rectifier.

Previous work on the development of titanium dioxide for rectifying devices has been reported by Breckenridge and Hosler[1] of the National Bureau of Standards, and by Peet and Middleton[2] and Shilliday and Peet[3] of Battelle Memorial Institute. In the last of these publications, room-temperature operation of TiO_2 rectifiers for times in excess of 2,500 hours was reported, as was operation for somewhat shorter lifetimes at temperatures up to 200 C.

Full text of a District paper presented at the AIEE Middle Eastern District Meeting, Columbus, Ohio, May 4–6, 1955, and recommended for publication by the AIEE Committee on Metallic Rectifiers.

H. C. Gorton, T. S. Shilliday, and F. K. Eggleston are with the Battelle Memorial Institute, Columbus, Ohio.

The authors wish to acknowledge the very helpful contributions to this investigation of Battelle staff member R. W. Willey. This research was sponsored by Wright Air Development Center under contract no. *AF33(038)-2460*.

The degree of reproducibility and an indication of the values of the electrical properties of the rectifiers produced at that time are shown in Fig. 1. These rectifiers were operated in half-wave circuits into parallel resistance-capacitance loads. A-c input voltage and load resistance were adjusted until the rectifiers were operating with a peak reverse voltage of 20 volts and a peak forward current density of 1 ampere per square inch of counterelectrode area. These adjustments were made with the aid of a calibrated cathode-ray oscilloscope. Peak readings were taken of current and voltage in the forward and reverse directions, and the forward voltage intercept was estimated from the display pattern on the oscilloscope.

Continued developmental work on TiO_2 rectifiers was directed toward increasing the degree of reproducibility of electrical characteristics. Further refinements in the processing procedure made it possible to observe the effects on the electrical properties of the rectifier of minute amounts of impurities originally present in the titanium metal or incorporated in the oxide by environmental contamination during processing. Attempts to detect and control these impurities have resulted in some rather surprising improvements in rectifier performance. The primary purpose of this article is to discuss these recent advances in TiO_2 rectifier development.

In particular, these improvements have resulted in a significant increase in the maximum temperature of operation. This effect and changes in other properties of the rectifiers, which will be explained later on, lead to the postulation of a different mechanism of rectification operat-

ing in the rectifiers produced by present techniques. Although it is beyond the scope of the article to discuss in detail the problems involved in experimental rectifier production, a brief description of the processing procedure should be helpful in understanding some of the data to be presented later.

Iodide-process titanium sheet is oxidized in an oxygen atmosphere to form a thin adherent film of oxygen-deficient TiO_2 on a metal base. Oxidation temperatures range from about 700 to 875 C. At temperatures in excess of 875 C., nonadherence of the oxide film becomes prevalent. However, experience has shown that rectifier characteristics (in particular, the reverse resistance and the maximum reverse potential) tend to improve as the oxidation temperature is increased. Even at optimum oxidation temperatures, however, rectifiers fabricated from TiO_2 without additional processing are characterized by rather high reverse leakage currents.

The reverse resistances of the rectifiers are materially increased by a process of anodization in a 5-per-cent sodium-hydroxide solution. The oxidized titanium sheet is used as one electrode, and a stainless steel plate is used as the opposing electrode. An alternating potential is placed across the bath and its magnitude adjusted to permit a current flow of from 2 to 10 amperes per square inch through the titanium dioxide electrode. A further oxidation of the titanium occurs during the anodization process, by which oxygen from the electrolyte is made available for reaction at the electrodes. Since higher current densities through the TiO_2 electrode occur at areas of lower resistance, a preferential oxidation takes place at those areas resulting in more uniform electrical properties of the TiO_2 film. The total charge passed through the oxide film is a determining factor in the bulk resistance of the oxide. Fig. 2 illustrates the general effect of anodization on the current–voltage characteristics of a typical specimen. This figure is a plot of applied forward and reverse direct potentials and the resultant currents. Although the forward resistance of the rectifier is somewhat increased by the anodization process, the ratio of reverse-to-forward resistance is also increased to such a degree as to justify the use of the process.

Previously, the oxide film has been contacted by vacuum evaporation of such metals as bismuth, antimony, and nickel to form counterelectrodes against the semiconducting oxide film. Earlier investigations have shown that the rectifying barrier in this type of rectifier exists at the counterelectrode-oxide interface with the barrier region, of course, extending into the oxide film. Of the different counterelectrode materials used, bismuth has shown the most favorable electrical characteristics. However, failure of the rectifiers after extended operation at elevated temperatures has generally been attributable to oxidation of the bismuth. Another objection to the use of bismuth is its low melting point of 271 C, which imposes an obvious limit to the ambient temperature of operation of the rectifier.

Certain modifications of the processing procedure described have resulted in two significant improvements in the TiO_2 rectifiers. Intentional doping of the oxide film with certain impurities has obviated the need for

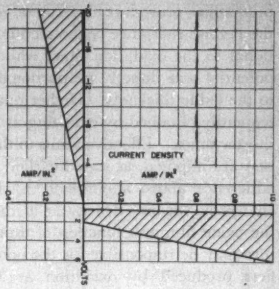


Fig. 1. Spread in dynamic current–voltage characteristics of 92 Bi-TiO_2 rectifiers

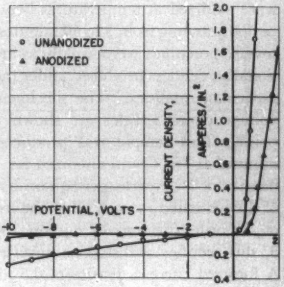


Fig. 2. Effect of anodization on a Bi-TiO_2 rectifier

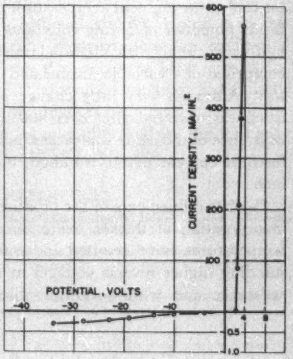


Fig. 3. Static current–voltage characteristics of TiO_2 rectifier

restricting the counterelectrode materials to a class of metals having work functions of particular values, as was previously the case. Experiments performed on the impurity-doped rectifiers indicate that the rectifying barrier may exist at an interface between two layers of oxide rather than at the metal-oxide interface. These rectifiers, electrically contacted with such materials as lead, graphite, brass, and silver paint, have been successfully operated for extended periods at temperatures in excess of 250 C.

The results of initial experiments with the modified

processing procedure indicated rather surprisingly that the reverse resistance of the rectifiers was inversely proportional to the oxidation time, while the maximum reverse potential was directly proportional, within certain limits, to the oxide thickness. Higher quality rectifiers were subsequently obtained by oxidizing at higher temperatures for shorter times. Effective limits to the temperature of oxidation are imposed, as stated earlier, by the problem of film adherence above about 875 C. It is postulated that a change in vacancy density or in the actual composition of the oxide film as a function of time at oxidation temperature may be responsible for the poorer quality of the rectifiers produced by oxidation at lower temperatures for longer times.

Rectifiers used in the aforementioned early experiments were oxidized at temperatures between 700 and 750 C for periods ranging from 5 to 60 minutes. Although maximum reverse potentials were usually as low as 5 or 6 volts, occasionally rectifiers produced under these conditions exhibited surprising qualities. The specimen whose static current–voltage characteristics are shown in Fig. 3 is a case in point. This sample was produced by oxidation for 10 minutes at 750 C and anodized for 10 minutes at a current density of 5 amperes per square inch. Photomicrographs of the sectioned rectifier show the oxide film thickness to be on the order of 0.1 to 0.2 micron. As can be seen from Fig. 3, this rectifier withstood a reverse potential of 34 volts. A forward current density of 0.5 ampere per square inch is observed at 4 volts forward voltage drop.

Rectifiers produced under these conditions were placed on test at an ambient temperature of 250 C under an a-c input potential of 5 rms volts and were operated into a half-wave circuit with a parallel resistance-capacitance load comprised of a variable resistor and a 1-microfarad capacitor. Although very little change in electrical characteristics was observed after over 400 hours on test, the bulk resistance of the oxide was rather high, limiting the average forward current density to about 0.25 ampere per square inch.

Further refinements in the production procedure and the incorporation of thicker oxide films produced at higher temperatures have resulted in rectifiers capable of withstanding higher reverse voltages at no sacrifice in reverse resistance and with a considerable decrease in forward resistance. Several specimens have been operated for extended times at elevated ambient temperatures at 5 and 10 volts rms input. These rectifiers also, as well as each of the others subjected to an alternating potential, were operated into half-wave circuits with parallel resistance-capacitance loads. Fig. 4 is a graph of the conversion efficiency of a representative 10-volt rectifier operating at 250 C ambient temperature. At 480 hours operating time, the power was taken off the rectifier for 16 hours. When the voltage was again applied to the rectifier, the conversion efficiency was observed to have increased from about 29 to 37 per cent. This value subsequently decreased to an average value of about 27 per cent. It was found that the conversion efficiency was critically dependent upon the input voltage, and the observed variations in the conversion efficiency–time curve can be accounted for by slight fluctuations in the input voltage. The conversion efficiency is a measure of the d-c output wattage divided by the a-c input wattage.

The static current–voltage characteristics of a similar 10-volt rectifier are shown in Fig. 5. The improvements achieved in the bulk resistance of the film and in the forward voltage intercept as a result of further refinements of the processing procedure are apparent. It may be observed that the bulk film resistance has been reduced by a factor of 4 and the forward voltage intercept by a factor of 2 over the 5-volt rectifiers. Table I lists forward and reverse current densities, and conversion efficiencies of this rectifier as a function of time on test at 250 C under 10 rms volts input. The load resistance was varied to maintain 200 milliamperes

Table I. Dynamic Characteristics of a 10-Volt TiO_2 Rectifier

Time on Test, Hours	Ambient Temperature, C	Forward Current Density, Ma/In^2	Reverse Current Density, Ma/In^2	Conversion Efficiency, Per Cent
0	25	200	1.2	10.8
2	250	200	< 0.01	24.2
47	250	200	0.50	25.0
71	250	200	1.8	25.8
95	250	200	1.4	26.6
185	250	200	6.0	25.8
257	250	200	13.4	25.0

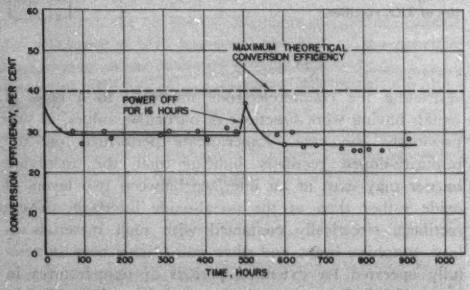


Fig. 4. Conversion efficiency of a TiO_2 rectifier operating at 250 C ambient temperature

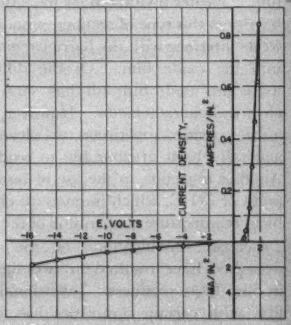


Fig. 5. Static current–voltage characteristic of TiO_2 rectifier operating at 250 C ambient temperature

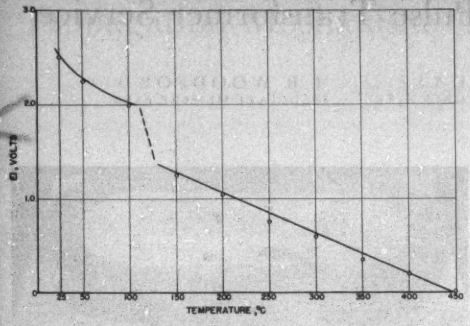
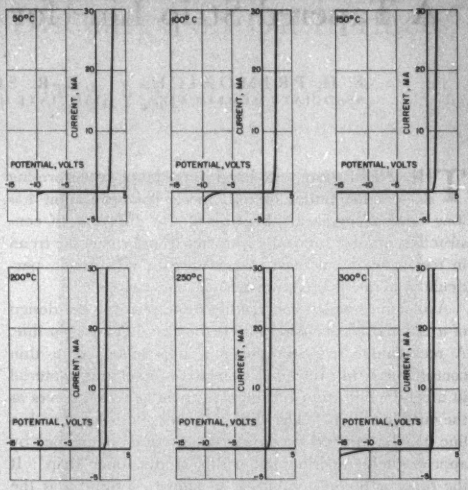


Fig. 6 (above). Temperature dependence of the forward-voltage intercept of a titanium-dioxide rectifier. Fig. 7 (right). Static current–voltage characteristics of a TiO_2 rectifier at the indicated temperatures



per square inch forward current density throughout the test.

Another sample from this group was held at 250 C for 100 hours before subjecting it to an applied potential. The rectifier was then subjected to an rms input potential of 15 volts and the load resistance adjusted to permit a forward current flow of 1.9 amperes per square inch. This rectifier was operated for 100 hours at 250 C without appreciable change in electrical characteristics.

Static current–voltage characteristics of a similar rectifier were observed at 50-degree intervals from room temperature to 450 C. Fig. 6 is a plot of the forward voltage intercept of the rectifier as a function of temperature. The discontinuity in the curve that occurs between 100 and 150 C is coincident with a forming of the reverse characteristic of the rectifier, as will be seen in Fig. 7. Above 150 C, a fairly linear relationship obtains, with the forward voltage intercept becoming zero at 450 C.

In Fig. 7, an increase in the reverse current is observed at −10 volts potential as the temperature is raised to 100 C. Between 100 and 150 C, the reverse resistance characteristically increases, and the rectifier becomes stable at higher reverse potentials. One can also observe in this series of curves, an expected decrease in the bulk resistance of the oxide with increasing temperature, as is indicated by the increasing slope of the forward characteristics. The decrease in forward voltage intercept with increasing temperature is also apparent. In this particular sample, some instability in the reverse characteristic was observed at 350 C and higher.

As more is understood of the mechanism of operation in the impurity-controlled TiO_2 rectifiers, continued improvement in and reproducibility of the electrical properties may be expected. Although the developments in the rectifier research program reported here are somewhat tentative in that relatively few specimens have been operated in the 200 to 300 C temperature range, it is definitely indicated that significant advances have been made in the maximum temperature of operation and in the forward-to-reverse resistance ratio of TiO_2 rectifiers.

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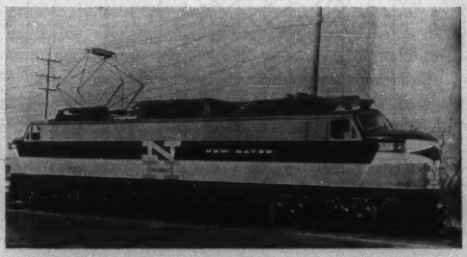
Rectifier Locomotive Tested

The first of the New York, New Haven and Hartford Railroad's new rectifier locomotives is shown as it went through tests at the General Electric Company's locomotive and car equipment department where it was built at Schenectady, N. Y. General Electric is building ten of these locomotives for operation between New York, N. Y., and New Haven, Conn. Electronic tubes in combination with a power transformer are used to change 11,000-volt 25-cycle a-c power into low-voltage direct current when the locomotive is operating in the a-c zone. It also operates in a d-c zone.



A Tapered Strip Line for Pulse Transformer Service

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THE NEED for wide-band impedance transforming devices for pulses of millimicrosecond duration has long been recognized. Because of the difficulty in constructing suitable lumped-parameter transformers the trend in recent years has been toward distributed systems, particularly of the tapered transmission-line variety.

A structure which can readily be applied to the design of a tapered transmission line is the rectangular strip line. A rectangular strip transmission line consists of a thin conducting strip suspended coaxialy in insulating material in a conducting right rectangular cylinder which serves as the outside sheath. The electrical characteristics of such a line can be tapered according to any desired manner by appropriately tapering the width of the inner strip. If the taper is not very rapid, it is valid to assume that the characteristic impedance at a point along the line can be determined from impedance curves for a uniform line. Curves of normalized impedance $\sqrt{k_r/u}\, Z_o$ vs. the dimensional ratio a/c, plotted for various values of b/c for a uniform strip line, are given in Fig. 1. With an air dielectric the range of impedance levels readily obtainable is 20 to 300 ohms.

An exponential strip line is shown in Fig. 2. This is an experimental "rolled-up" model which was designed to be 10 meters long. The impedance level at the low end is 25 ohms and at the high end, 100 ohms. The total dimensions of the line in Fig. 2 are about 2 feet by 4 feet. This line was used successfully to transform pulses as long as 36 milliseconds in duration.

In an exponential strip line the characteristic impedance at a point varies as an exponential function of the distance from the sending end, thus

$$Z_x = Z_o e^{\gamma x} \qquad (1)$$

where γ is the flare coefficient, x is the distance from the sending end of the line, and Z_o is the characteristic impedance at the sending end. The pulse response of the exponential line and the criteria for the design of such lines as pulse transformers have been established previously.[1] After the length and flare requirements have been established for a particular pulse application it is only necessary to taper the center conductor, or strip, of a rectangular strip line in such a way that the characteristic impedance along the line will follow that given in equation 1. From equation 1 the impedance at a given position x on the line is known. For given values of b and c the value of a necessary to give the required value of impedance at the point x can be determined from Fig. 1. The dimensions at the sending end of the line are, of course, functions of desired impedance level, space limitations, and breakdown and power-handling requirements.

The rectangular strip line is suited to tapered transmission-line design because of ease of construction. It is a space-saving cost-reducing device which may make the use of tapered transmission lines more practical.

Fig. 2. Experimental "rolled-up" exponential strip line

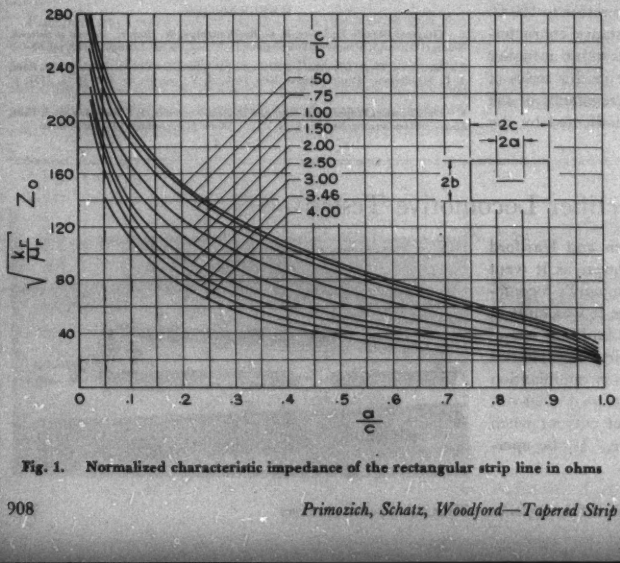

Fig. 1. Normalized characteristic impedance of the rectangular strip line in ohms

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Propagation Mechanism of Discharge on Oil Surfaces

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THIS study of the propagation mechanism of impulse creepage discharges over oil-immersed Kraft board was carried out using Leica and high-speed Boys cameras to record the progression of the discharges, as well as a special probe technique to measure the discharge potentials at various points along the channel. The electrode configuration used in these experiments consisted of a rod electrode on one side of a sheet of 1/8-inch Kraft board and a grounded copper surface deposited on the opposite side. Capacitance probes were imbedded in the copper surface to measure the approximate potentials of streamers passing along the rod side of the insulation. Impulse waves of 1.5 × 7,000 microseconds were applied to the rod at 120 kv which was about three times the corona starting level. The entire test structure was placed in a lucite tank filled with commercial-quality insulating oil. Photographs of the discharges were made through the walls of the tank by means of a slit and mirror arrangement. The Kraft board insulation used in these tests was first impregnated with oil under vacuum, and transferred to the testing tank just before tests were begun.

High-speed photographs and oscillograms of a negative-polarity creepage streamer are shown in Fig. 1. The photograph shows that the streamer travels over the insulation surface in a manner remarkably similar to natural lightning, except on a greatly reduced scale. The propagation mechanism of natural lightning has been postulated by Schonland and others as consisting of a faint pilot streamer moving ahead of a series of bright stepped streamers progressing from cloud to ground. This streamer has never been photographed in the lightning discharge due to its faint luminousity. However, examination of the channel potential oscillograms in this experiment reveals that a negatively charged region propagates steadily ahead of the bright discrete-stepped streamers in a manner indicative of the presence of a pilot-streamer mechanism.

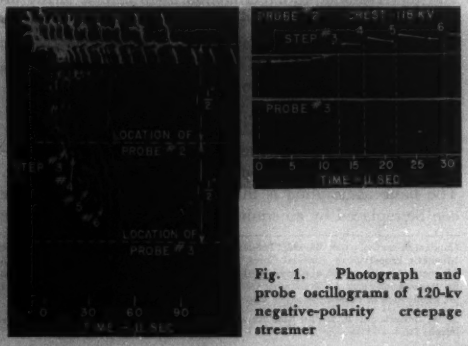

Fig. 1. Photograph and probe oscillograms of 120-kv negative-polarity creepage streamer

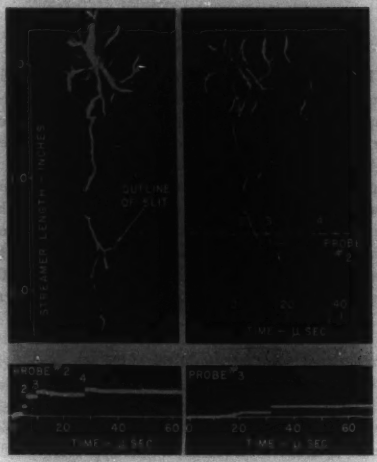

Fig. 2. Photographs and probe oscillograms of 120-kv positive-polarity creepage streamer

By considering the existence of a pilot streamer, the entire channel potential variations can be explained. It is indicated that the stepped streamers are formed as a result of periodic electron emission from the electrode. This emission is formed by high space-charge fields produced by the advance of the pilot streamer.

The positive polarity propagation is shown in Fig. 2 to be a series of discrete-stepped discharges of increasing length. The photographs show that the channel lengths, times of occurrence, and branching are much more erratic than in the case of negative polarity. The channel potentials also differ from negative in that the potentials become more step-like and do not show the pronounced rise and fall associated with negative discharges. In addition, there is no evidence of a pilot streamer moving ahead of the discharge, nor is such a streamer believed necessary to explain positive polarity propagation. Available evidence indicates that each stepped discharge appears to be somewhat similar to positive streamers in air (with additional differences of charge mobilities), and that branching and subsequent discharges are due to charges clumping in the channel at weak points. Over-all speeds of propagation shown in the figures are about 1/10 inch per microsecond.

Digest of paper 55-56, "The Propagation Mechanism of Impulse Creepage Discharges over Oil-Immersed Surfaces," recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Communication and Electronics*, May 1955, pp. 218–26.

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Influence of ID-OD Ratio on Magnetic Properties of Toroidal Cores

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The optimization of toroidal core shapes for use in self-saturating magnetic amplifiers requires a knowledge of the influence of id-od ratio on apparent core magnetic properties. A theoretical result was derived assuming a parallelogram-shaped basic hysteresis loop and an elaborate experiment was performed. The possibility of doubling the gain of a push-pull amplifier stage by changing the core height and radial build-up to increase the id-od ratio without changing the iron area was shown.

THE MAGNETIC PROPERTIES of a closed core in which all flux lines do not have nearly the same lengths differ from those of a thin-ring sample of the same material. Although this phenomenon is not of major importance in transformer design, it does appreciably influence the characteristics of high-performance self-saturating magnetic amplifiers. The need for an investigation of the effect of the inside diameter-outside diameter (id-od) ratio of toroidal cores on their magnetic properties arises when attempts are made to calculate optimum core shapes for magnetic amplifier applications. Satisfactory expressions are known for the effect of the other core shape factors affecting amplifier performance, e.g. mean magnetic path length, cross-section area, and window area. A simple experiment using two cores indicated that the id-od effect might be quite large, but no satisfactory expression for it was found during a review of the literature.

McConnell[1] has investigated the influence of id-od ratio on static properties of toroidal cores, but his results are inconclusive. Dieterly[2] has published a study of dynamic hysteresis loops under sine flux conditions showing that loops for cores with low values of id-od ratio are sheared over with respect to the loop for the basic material. The application of Dieterly's results to magnetic-amplifier performance is not apparent because of the lack of any known correlation between dynamic loops and the performance of amplifiers with relatively high control circuit impedance.[3]

The approach taken in the present article is as follows: If a relationship could be found between amplifier performance and a hypothetical (effective) dynamic hysteresis loop, then an effective loop could be determined experimentally for a thin core, i.e. one with id-od ratio approximately unity. Such a loop expresses a basic property of the magnetic material since it is not influenced by core geometry. The effective hysteresis loop corresponding to any id-od ratio might then be calculated using an approach similar to that of McConnell. It is then to be hoped that the previously mentioned relationship between amplifier performance and effective hysteresis loop could be used successfully to predict amplifier performance for any id-od ratio.

Lehmann[3] and others [4,5] have pointed out the relation between amplifier performance and a *B-H* plot called a control magnetization curve. The latter, although actually a locus of points on a series of minor hysteresis loops, has a form similar to a portion of the left flank of a major hysteresis loop. Carrying out this analogy by adding a symmetrical right flank, an effective hysteresis loop corresponding to magnetic-amplifier operation is obtained, and the program of the previous paragraph becomes possible to carry out.

At the outset the work reported here was restricted to toroidal cores, though similar results could probably be obtained for other shapes. Reasons for this restriction included the mathematical and experimental simplicity of the toroidal geometry as well as the practical importance of toroidal cores in magnetic-amplifier applications.

Theoretical results for the influence of id-od ratio on the hysteresis loop for two different types of basic material loops, and the results of an experimental investigation of the influence of id-od ratio on the static loop and a-c control magnetization curves for a typical magnetic-amplifier core material are presented. The two are compared to determine the validity of the theoretical treatment.

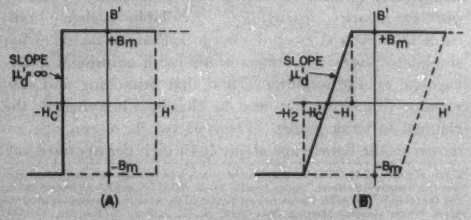

Fig. 1. Assumed forms of B-H loops

THEORETICAL RESULTS

THE RESULTS of a theoretical calculation of the dependence of the *B-H* relation on id-od ratio will now be given. The basic assumption is that a tape-wound toroidal core can be replaced by an equivalent core consisting of a large

Condensed text of paper 55-538, "Influence of ID-OD Ratio on Static and Dynamic Magnetic Properties of Toroidal Cores," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Swampscott, Mass. Scheduled for publication in *Communication and Electronics*, 1955.

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number, infinite in the limit, of thin closed concentric rings. A second assumption is that a thin ring of the magnetic material has a parallelogram-shaped *B-H* loop.

Rectangular Loop. The first case considered is that of the perfectly rectangular loop, Fig. 1*A*. By the same method used by McConnell[1] the average flux density B as a function of the magnetic field intensity H at the mean radius, $(R_2 + R_1)/2$ is found to be

$$B = \frac{R_2+R_1}{R_2-R_1}\left(1+\frac{H}{H_c'}\right) B_m \qquad (1)$$

The slope of this straight line is termed the differential permeability, μ_d. Expressed in terms of r = id/od, it is

$$\mu_d = \frac{dB}{dH} = \frac{1+r}{1-r} \times \frac{B_m}{H_c'} \qquad (2)$$

A plot of this function is shown in Fig. 2.

Parallelogram Loop. The second form of *B-H* loop considered is shown in Fig. 1*B*. As can be seen from Fig. 3, it is necessary to distinguish between two cases, thin core and thick core. A thin core has all of its rings unsaturated for some range of mmf values, while a thick core always has some rings saturated. In both cases, the calculated *B-H* relation has linear regions.

For the thin core case, $r>h = H_1/H_2$, the ratio of the differential permeability in the linear region to the slope μ_d' of the flank of the elementary loop is found to be:

$$\frac{\mu_d}{\mu_d'} = \frac{1}{2}\left(\frac{1+r}{1-r}\right) ln\frac{1}{r} \qquad (3)$$

For the thick core case, $r<h$, the result is:

$$\frac{\mu_d}{\mu_d'} = \frac{1}{2}\left(\frac{1+r}{1-r}\right) ln\frac{1}{h} \qquad (4)$$

Fig. 4 shows graphically the meanings of equations 3 and 4. The parameter h is determined by the core material used. As the build-up of the core is increased, i.e. r is decreased, the differential permeability at first changes only slightly, thin core case. Then a break point is reached:

$$r_b = h = \frac{\mu_d' H_c' - B_m}{\mu_d' H_c' + B_m} \qquad (5)$$

following which the permeability decreases sharply, thick core case.

Coercive Force. The rectangular loop case gives, $H_c = H_c'$, a constant independent of the id-od ratio as can be shown from equation 1. The thin core case gives:

$$\frac{H_c}{H_c'} = \left(\frac{\mu_d}{\mu_d'}\right)^{-1} \qquad (6)$$

which is very nearly constant, as shown by equation 3 and Fig. 4. The thick core case gives:

$$H_c = \left[\frac{1}{2}\mu_d'\left(\frac{1+h}{1-h}\right) ln\frac{1}{h}\right]^{-1} \qquad (7)$$

which is a constant.

EXPERIMENTAL

Experimental Approach. The technique used to investigate experimentally the influence of core id-od ratio on static and effective dynamic core magnetic properties was as follows: Using a nickel-iron alloy extensively employed in magnetic amplifiers, a group of cores were manufactured having as large a radial build-up (small id-od ratio) as possible. These cores were placed in specially constructed high-rigidity protective boxes; the necessary windings were applied; and electric tests were made to determine the desired magnetic properties. Then the windings were cut off; the boxes opened; and with extreme caution, a portion of the core was removed by clipping wraps of strip from the inside of the core. The resultant cores, having an increased id-od ratio but unchanged basic material properties, were then retested for net magnetic properties. This procedure was repeated several times until there was so little core material left that electrical testing became impractical.

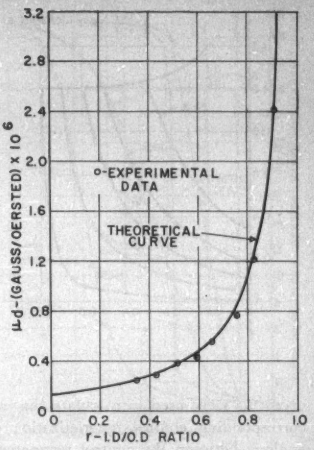

Fig. 2. Typical μd vs. r plot for static test: Core A

The set of electrical measurements made at each step in the reduction of core size consisted of the following: (1) flux meter measurements of the left flank of the major static hysteresis loop; (2) control characteristic curve of half-wave self-saturating amplifier with 60-cps supply frequency; (3) control characteristic curve of half-wave self-saturating amplifier with 400-cps supply frequency, and (4) constant-current-flux-reset core test[5] characteristic curve for a 400-cps test frequency.

Data from the half-wave amplifier and core tester meas-

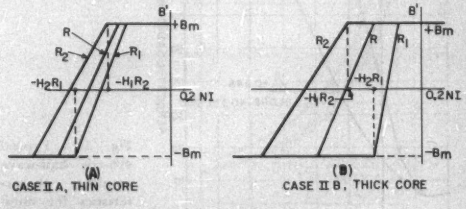

Fig. 3. Flux vs. mmf for elementary rings: *Case IIA—Thin core; Case IIB—Thick core*

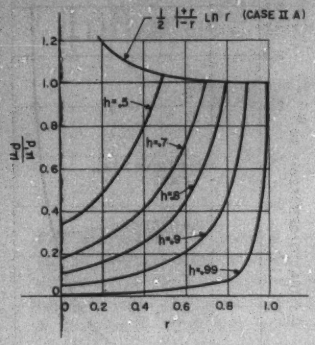

Fig. 4. Effects of id-od ratio and material characteristics on differential permeability: *Cases 11A and 11B*

urements were used to calculate the important features of corresponding control magnetization curves. Using the analogy between the control magnetization curve and an effective major dynamic hysteresis loop, values of effective magnetic quantities, such as coercive force, saturation flux density, residual flux density, and differential permeability, can be defined. The effective magnetic quantities calculated from the half-wave amplifier data were coercive force and differential permeability. From core tester measurements, values of saturation and residual flux density were found in addition to coercive force and differential permeability. By plotting the experimentally determined values of static and effective dynamic magnetic quantities as a function of id-od ratio, a comparison was made with the theoretically derived relationships.

It was expected that if the approach taken were valid, then the plots of magnetic quantities vs. id-od ratio for the various types of electrical measurements would compare with the theoretical expressions as follows: Static hysteresis loops, for the type of magnetic alloy being considered, have nearly vertical sides; thus the static magnetic quantities should vary with id-od ratio according to the relations derived under the theoretical Case I (Perfectly Rectangular Loop). Control magnetization curves for half-wave amplifier operation or for core tester operation have finite slopes or differential permeabilities even for cores with very small radial build-up. Further, the values of differential permeability are known to decrease with increasing operating frequency. Thus effective dynamic magnetic quantities should vary with id-od ratio approximately according to the relations derived under the theoretical Case II (Parallelogram Loop with $B_r = B_m$), and the results for the two different test frequencies should be similar except for a shift in the basic material values of H_c' and μ_d'. The results from the 400-cps core tester measurements were expected to be nearly identical to those from the 400-cps half-wave amplifier measurements. They were included both as a further check on the correlation between core tester and amplifier operation, and as a check on the applicability of the theoretical results under slightly altered core operating conditions.

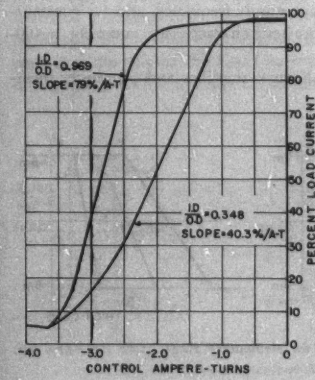

Fig. 5. Typical 400-cps half-wave amplifier characteristics for minimum and maximum id-od ratio

Core Details. The magnetic alloy chosen for the experimental investigation was Hipernik V, a grain-oriented 50-per-cent nickel-iron alloy similar in properties to Deltamax Orthonol, Orthonik, etc. This material was used because of its ready availability and widespread use in magnetic amplifiers. The particular strip selected was of 2-mil thickness and $^1/_4$ inch width and was chosen from a number of available batches or melts as having the desirable characteristics of being relatively insensitive to minor variations in annealing treatment and of normally yielding cores having a small variance of magnetic properties. The static magnetic properties normally obtained with this material are $H_c = 0.11$ oersteds, $B_m = 14.6$ kilogauss, and $B_r/B_m = 0.96$ for a tip H of 2 oersteds. Four cores were wound from this strip to an over-all size of 1.90 cm id × 5.5 cm od × 0.635 cm height with approximately an 80-per-cent space factor.

Electrical Measurements. Static *B-H* loop measurements were made with a standard commercially available flux meter (not a ballistic galvanometer) but in a somewhat unconventional manner. To maintain the same mode of core operation as in a magnetic amplifier down to zero frequency, the cores were operated statically over a series of minor hysteresis loops similar in form to those traversed in magnetic amplifier operation. This was accomplished by driving the flux nearly to positive saturation with a large positive applied mmf. Then the applied mmf was switched to a controlled negative value and the resulting flux change measured. Thus the static test results were presented in terms of total flux density change from saturation level as a function of the mean magnetizing force corresponding to the controlled negative mmf. The component values for the half-wave amplifier test circuits were, of course, different for each test frequency and each cut in core size. However, certain design factors were held constant in each case. These were the values of a-c supply voltage and load resistance which were adjusted so that the core would be driven from positive to negative saturation, with the amplifier at cutoff, and to a peak mmf 20 times the effective hysteresis loop width with the amplifier at maximum output. In addition, vacuum tube rectifiers were used for self-saturation

and were selected to have a peak forward drop less than 20 per-cent of the a-c supply voltage.

Constant-current-flux reset core tester measurements were made as described in ref. 5. Briefly, an excitation mmf having a half-wave rectified waveform and a peak value sufficient to drive the flux to saturation is applied to the core. A separate d-c control mmf is also applied which, when negative, resets the flux during the zero half-cycles of excitation mmf. A special average-sensitive meter is used to measure the induced voltage in a separate pickup winding on the core. The test consists of measuring the induced voltage as a function of the control mmf. Details of the conversion of this type of data to a control magnetization curve are given also in ref. 5.

Experimental Results. In Fig. 5 are shown typical 400-cps half-wave amplifier control characteristic curves, for the maximum and minimum values of id-od ratio. The curves shown are for one of the four cores tested, but results for the others were very similar. The increase of slope due to increased id-od ratio is evident. The value of control current for cutoff, i.e., the ampere turns necessary to reset completely the outside ring of the core, remains approximately independent of the id-od ratio because the latter was varied by removing wraps from the inside of the core. The nonlinearity apparent at low values of output is caused by "backfiring"[8] within the gate circuit of the amplifier during reset. While the reset waveform was observed to change somewhat as id-od ratio was varied, backfiring is primarily due to the characteristics of the material used. The backfiring effect completely masked any linearity variations due to varying id-od ratio.

The typical 400-cps core test curves of Fig. 6 are seen to be closely similar to the corresponding amplifier curves of Fig. 5. The static test curves, also in Fig. 6, exhibit a higher slope than the dynamic test curves.

Differential permeability vs. id-od ratio for typical static test data are shown in Fig. 2. The individual data points shown correspond to actual measurements of the average slope of the static loops, while the solid curve is a plot of the theoretical relation

$$\mu_d = K\left(\frac{1+r}{1-r}\right) \qquad (8)$$

where the value of K is determined for best fit of the data. Similar plots for the other cores were very nearly identical except for slight variations in the value of K for best fit. Effective differential permeability vs. id-od ratio for the dynamic tests is plotted for one of the four cores tested in Fig. 7. Again the individual points represent actual measurements while the solid curves are plots of the theoretical relation with the constant K chosen for best fit. It will be noted that the fit of data points to the theoretical curve is not as close as for the static test results, but that there is certainly strong evidence of reasonable agreement. The very sharp break predicted theoretically is not clearly proven or disproven but there is certainly a region of high id-od ratio values where the differential permeability values are nearly constant and the rapid reduction for lower id-od values is clearly indicated.

In each case a random divergence of data points for high id-od values was apparent. It was probably caused by the difficulty in measuring accurately the higher gain values.

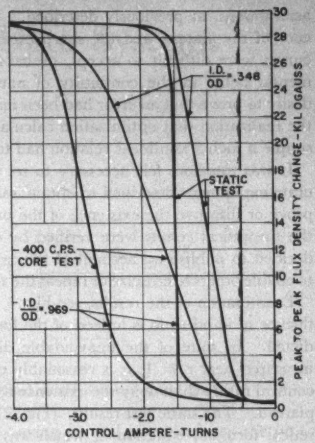

Fig. 6. Typical static and 400-cps core test data for minimum and maximum id-od ratio

DISCUSSION AND CONCLUSIONS

The importance of investigating the effect of id-od ratio on core gain was first realized when attempts were made to calculate optimum core dimensions for magnetic-amplifier applications. All the other factors affecting amplifier performance, such as winding space factor and winding resistance, could be approximated satisfactorily. It was known from tests on two cores of widely different id-od ratios only that the effect on gain was by no means negligible, being more than 50 per cent in this instance.

The theoretical results presented graphically in Fig. 4 were then derived on the basis of the simplest reasonable

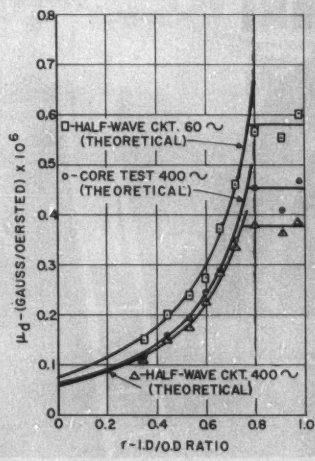

Fig. 7. μ_d vs. r for dynamic tests

assumptions, as previously described. The physical existence of the plateau and the sharp break predicted by the curves were difficult to accept, probably due to a fundamental belief in the continuity of nature. Further, the desire to prove that an error had been made was fostered by the realization that optimization calculations would not be simple if such a nonlinear relation had to be used.

It was therefore felt necessary to set up the rather elaborate experiment described to obtain reliable data and to prove or disprove the existence of the break. Then, since the theoretical results were verified by experiment, it was decided to publish an account of the experimental details, to enable others to criticize or repeat the work.

Examination of the results, see Fig. 7, shows that the influence of id-od ratio is indeed of the form which was predicted. In spite of the unavoidable dispersion of values measured near $r = 1$, it is reasonably clear that the data confirm rather than deny the existence of a break point and plateau. The static test results, (Fig. 2), verify the theoretical formula, equation 2, which was also given by McConnell.[1]

A direct consequence of the theoretical results shown in Fig. 4 is that to realize maximum gain from a material having a high value of h it is necessary to make $r > h$. The resulting core shape may have smaller radial build-up than is ordinarily found in commercially available cores. Limited experimentation with cores of Hymu 80 alloy, a Mo-Permalloy material, disclosed that, on the basis of core tester measurements at 400 cycles, a change in id-od ratio from 0.66 to 0.80 caused effective μ_q to change from 500,000 to 1,000,000, while a further increase of r to 0.89 gave a negligible change in μ_q. These results were obtained with separate groups of cores wound to the various values of id-od ratio, rather than the technique used to vary id-od previously described. It is of interest to note that immediate practical use was made of the increased μ_q available with the increased id-od ratio. It was possible to double the inherent gain of the first stage of a 2-stage all-magnetic servo amplifier by the simple expedient of doubling the strip width and halving the radial build-up of the first stage cores.

When considering the application of the results found here to the design of cores for magnetic amplifiers, the first thought is to restrict core radial build-up so as to be always in the thin core region. However, this is not necessarily an optimum condition for all applications. Other considerations such as output power and toroidal winding restrictions may well outweigh the influence of id-od ratio on basic core gain. However, in the design of a core for any particular application, the influence of core id-od ratio must certainly be known and taken into account.

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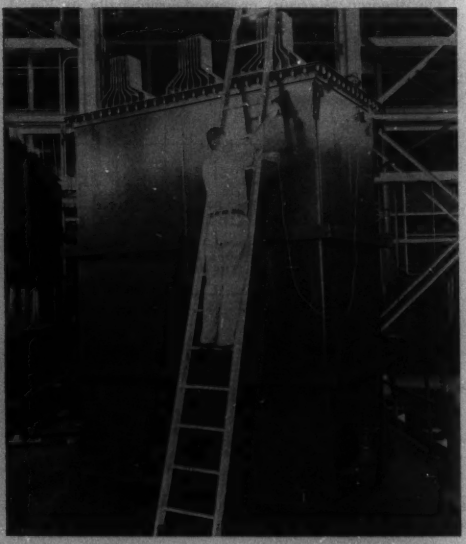
Furnace Transformers Built for Steel Mill



Two furnace transformers for New England's first specialty steel mill were made recently by the General Electric Company's power transformer department, Pittsfield, Mass.

They were built for the Pittsburgh Lectromelt Furnace Corporation, which is supplying two arc-melting furnaces for the Northeastern Steel Corporation at Bridgeport, Conn. The transformers, about 15 feet high and weighing 32 tons apiece, traveled on drop-bed railroad flat cars and highway trailer trucks to Bridgeport.

Power for the furnaces will be supplied at 13,800 volts, and the transformers will "step down" the voltage from this level to the low-voltage high current required to melt the steel charge in the furnaces at 6,000 F. Each transformer can supply its furnace with a maximum of 29,460 amperes.

The transformers are rated 10,000 kva, and each is provided with a circulating pump and heat exchanger to raise its rating to 12,500 kva. A 6-position tap changer, electrode regulators, switchgear, and auxiliary motors and controls will enable the operator to regulate the furnace.

The Pittsfield plant is also supplying three large current-limiting reactors. These will be used in conjunction with a 20,000-kva synchronous condenser to regulate the voltage at the terminals of the transformers.

Transient Response of Sampled-Data Systems

E. I. JURY
ASSOCIATE MEMBER AIEE

IT IS KNOWN that the z-transform method[1-4] can be readily used for analysis and design of sampled-data systems. This method is essentially a Laplace transform technique in which the sampled output is related to the input by system functions in the form of z-transforms. These system functions can be generally regarded to consist of zeros and poles, in the form of rational polynomial in the variable z, where z is defined as ϵ^{Ts} and T is the sampling period. The purpose of this digest is to investigate in detail the effect of the locations of the poles and zeros of the transfer function on the transient response of sampled-data systems when subjected to step input.

Normalized Time-Sequence Response. To provide sufficient generality, it is assumed that the sampled-data system shown in Fig. 1 has a transfer function (output/input) containing l pairs of conjugate poles, q simple poles, g pairs of complex zeros, and m real zeros, in the z-plane. It is also assumed from physical realizability that $2l + q > 2g + m$. If this system is subjected to a unit-step input, it can be shown that the following expression is obtained for the normalized time-sequence response:

$$C_0(nT) = 1 + \sum_{k=1}^{l} M_k \frac{\beta_{0k}^2}{\beta_k[(\alpha_k - 1)^2 + \beta_k^2]^{1/2}} [\alpha_k^2 + \beta_k^2]^{n/2} \times \sin[n\theta_k + \lambda_k + \psi_k] + \sum_{k=1}^{q} (-1)^{k+rk} N_k(\rho_k)^n \quad (1)$$

in which M_k and N_k are the quotient of the product of factors due to zeros divided by the product of factors due to poles, and r_k is the number of real zeros whose magnitude is greater than $|\rho_k|$ in the z-plane. Thus the normalized response $C_0(nT)$ can be readily investigated from the location of the poles and zeros in the z-plane.

Two Time-Response Theorems. As a result of the condition $2l + q > 2g + m$ or $\underset{n\to 0}{C}(nT) = 0$, it is shown that the following theorems exist. Theorem Ia: The transient sequence response to a step-function input of a linear sampled-data control system, having no real poles between the unit circle and the circle representing the first pair of complex poles, cannot be monotonic. The z-transform of the form presented in this digest yields the response at sampling instances only. However, the foregoing theorem can be extended to include the actual response between sampling instances, for if the sampled output cannot be monotonic it necessarily follows that the output between sampling instances is also nonmonotonic, thus, Theorem Ib: The transient response to a step-function input of a linear sampled-data control system having no real poles between the unit circle and the circle representing the first pair of complex poles cannot be monotonic. Theorem II: In order that the transient-sequence response to a step function of a sampled-data system, having its real pole on the perimeter of the same circle on which the first pair of complex poles lie, increase monotically, it is necessary that the number of real zeros larger than the real poles in the z-plane be zero or even, and that the quantity $(n_1'\beta_1/\rho_{11})$ be equal to or greater than the maximum value of $\sin(n\theta_1 + \lambda_1)$.

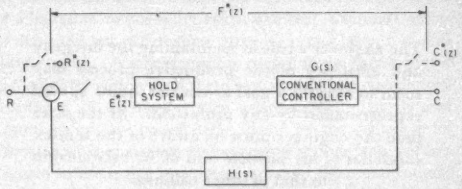


Fig. 1. Typical sampled-data control system

Dominance of the Normalized Time-Sequence Response. It can be shown that when all real and complex poles except a dominant pair exist near the origin in the z-plane, the output $C_0(nT)$ given in equation 1 can be approximated in the following expression:

$$C_0(nT) = 1 + M_1 \frac{\beta_{01}^2}{\beta_1[(\alpha_1 - 1)^2 + \beta_1^2]^{1/2}} (\alpha_1^2 + \beta_1^2)^{n/2} \sin(n\theta_1 + \lambda_1 + \psi_1) \quad (2)$$

From this expression, it can be shown that computation of the location and magnitude of the maxima and minima can be simplified considerably. Furthermore, the effect of the various poles and zeros on the location and magnitude of the maximum response can be quantitatively prescribed which would indicate the deviation from the maxima of a second-order system.[4] Finally, certain of the methods presented here, in addition to their use in analysis, can also be applied in the solution of design problems in sampled-data systems to yield prescribed time-sequence responses to step-function inputs.

Appendix

n_1' = factor due to zero-pole location in the z-plane.
β_1 = location of the real pole in the z-plane.
ρ_{11} = distance in the z-plane between the real pole and complex pole.

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The Philosophy of Codes of Ethics

L. L. FULLER

The engineer's role in maintaining the integrity and efficiency of the productive process may seem so obvious a goal as not to require special representation by any profession. At the same time the engineer must be aware of the hidden subtleties of his mission and of its relationship to that of other callings.

THE STANDARDS of conduct for any profession or calling should be derived from: (1) an understanding of those general principles of social organization that must be observed in order that men may live in harmony with one another and at the same time realize their full potentialities as individual human beings; and (2) an understanding of the peculiar function which the profession in question performs in the total processes of society.

With respect to those principles that should govern the ordering of society as a whole, Western thought at present wavers uneasily between two equally dangerous absolutes. One of these is the absolute miscalled cultural relativism. This view is miscalled relativism because it converts cultural influences and existing institutional arrangements into an absolute. It asserts that nothing can be said about the proper ordering of society that transcends the influence of the immediate social environment. What is "right" or "wrong" depends entirely on what one is used to; ethical standards become in essence a matter of conditioned reflexes. As to conscious efforts directed to the improvement of society, this view permits no middle ground between complete conservatism and a legitimation of every conceivable kind of change. If ethical standards are entirely a matter of tradition and usage then, says the conservative, we must hold blindly to what we have lest all be lost. On the other hand, if what we now have can make no claim to our respect beyond the fact that it exists and that we are used to it, then the reformer may assert that he is justified on grounds of unarticulated personal preference in working for any change whatsoever that seems good to him.

The absolute opposed to that just described is a view asserting that ethical standards are independent of time, place, and circumstance. Right is eternally right whether one is in Africa, Korea, or Kansas; whether the world is at war or at peace; whether one is dealing with an enemy or a friend; whether one is trading on the market or making a contribution to charity. This view makes every imperfection of social arrangements a compromise of principle; instead of concerning itself with the task, for example, of reducing social friction to a minimum, this view remains wrapped in its dream of a hypothetical frictionless society. This view can be stated differently by saying that it asserts that ethical ends can and indeed *must* be selected in abstraction from means. It regards any consideration of means, or of means-cost, as an abandonment of the field of ethics for that of prudential calculation.

Like the view miscalled cultural relativism, this conception offers no middle course between complete inertia and unprincipled change. In actual life social change always involves a reciprocal adjustment between ends and means. To achieve an end that seems desirable we must cast about for some feasible means, the costs of which will not outweigh the end to be gained. Usually in the process of reciprocal adjustment between ends and means, the end will be modified or redefined. Current ethical theory offers almost no guidance for the conduct of this vital procedure of reciprocal adjustment, though the problem of adapting means and ends to one another is involved in every arrangement that men set up to regulate their relations with one another.

NATURAL LAWS OF SOCIAL ORDER

To escape from the sterile absolutes that are now generally offered to us we must return to a realization that there are natural laws of social order—laws that are "natural" in the sense that they are given, laws that we do not know instinctively but must use our minds and our powers of observation to discern and understand.

It is difficult to illustrate what is meant by these natural laws of social order because examples tend either to be too complex for brief exposition or too simple to make any impression other than that of triviality. It does not seem, for instance, a profound observation to remark that the social institution of adjudication loses its whole reason for being if we have no restriction against the bribing of judges. Perhaps a less obvious aspect of the institution of adjudication would be more helpful in clarifying the meaning. The arbitration of labor disputes performs a useful and essential role in our industrial society. Those who have a first-hand acquaintance with this institution know that arbitration is used sometimes as a means of making palatable what is, in fact, an agreed settlement. To those who engage in this practice it seems innocent and even highly beneficial. Yet it is apparent that this use of arbitration is essentially parasitic and derived. If all arbitration awards were agreed on in advance there would be no point in clothing a settlement with the form of an award; the award would lose that special moral force in men's affairs that makes it occasionally useful as a kind of sugar coating. If we are to preserve the utility of arbitration as an institution we must, therefore, eliminate or restrict narrowly the use of the award

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as a means of securing acceptance for a negotiated settlement.

SOCIAL INSTITUTIONS

So it is with all social institutions. We must ask of them what purposes they serve in society and then reason out what restraints must be observed if those purposes are to be achieved. When a creative responsibility toward social institutions is assumed, we are no more free to follow our whims and impulses of the moment than is an electrical engineer who undertakes to design a circuit for a specified purpose.

Therefore, whether, we are drafting a constitution or designing an electrical circuit, we are dealing with something bigger than ourselves; we must understand and respect those laws that naturally govern the reality we seek to mold. With respect to social institutions there is, however, a peculiar difficulty not present when we are dealing with inanimate matter. The fact is, existing social institutions constitute a part of the resistant reality with which we are confronted.

When we are in the area of prudent calculation rather than that thought of as "ethics" in the strict sense, this point does not cause great concern. For example, it is conceivable that psychological and physiological studies might reveal that in a society starting anew, fewer traffic accidents would happen if we adopted the English rule of passing on the left rather than our own of passing on the right. But if this were so, it would be obvious that we would have to weigh against this theoretical advantage the fact that millions of automobiles with a left-hand drive are now in use in this country, and millions of Americans have the habit of passing on the right deeply ingrained in their nervous systems. Taking these realities into account seems the plainest common sense, to which it would appear perverse to apply the term "compromise" in any derogatory sense.

Though it is no more intelligent to pass a moral judgment in abstraction from existing social institutions than it is to pass a similar judgment about traffic regulations, there attaches to the field of ethics a flavor that makes distasteful any recognition that a thing can be right in part because it exists. It seems to be a tacit premise of most ethical theory that we are to think of society as being built from the ground up, so that nothing less than Utopia will do. This was not the view of Socrates, however, who out of respect for the going concern that was Athens felt obligated to obey the decree of a tribunal he considered both stupid and prejudiced. Nor was it the view of Aristotle who, though he was certainly no cultural relativist in the modern sense, nevertheless wrote, "Perhaps it is not in all cases the same thing to be a good man simply and to be a good citizen under a particular system of government." The forms and restraints which make our living together possible are created by us, but they in turn help to make us what we are and to define what we should do toward one another.

Some people feel great discomfort in the presence of a view that asserts, on the one hand, that there are objective principles for constructing a good society and, on the other, that those principles are themselves modified by the existing institutions of the society to which they are applied. But it is suggested this discomfort is really the discomfort of being alive. For it is a characteristic of the living organism to interact with its environment, to adapt itself in part to its surroundings, and at the same time to reshape those surroundings to its needs, then to react in turn to the environment that it has in part created. Wherever there is life there is constancy of direction combined with the power of adaptation to changing circumstances; eliminate either of these and you are dealing, not with protoplasm, but with dead matter. A machine is like a man to the extent that it incorporates within itself these two seemingly contradictory attributes of constancy and adaptability. The almost cosmic emphasis occasionally given to the principle of "feedback" is in essence an expression of this fact. If imbedded in life is this interaction between the organism and its environment, there is no reason to suppose that we can escape it when dealing with the problem of building the good society.

ROLE OF A PROFESSION IN SOCIETY

So much for the starting point in constructing an ethical system to regulate generally men's life in common. With respect to each separate profession we must begin by analyzing the function it performs in society. When we know what role a profession plays in the total processes of society we shall then know how that role should be played and what restraints must be observed to make it most effective.

A code of ethics must contain a sense of mission, some feeling for the peculiar role of the profession it seeks to regulate. A code that attempts to take the whole of right and wrong for its province breaks down inevitably into a mush of platitudes.

A code of ethics for the engineering profession would be animated by three special interests or concerns in an ascending scale of importance: (1) the integrity and efficiency of the productive process; (2) technological progress; and (3) the advance of scientific knowledge about reality. However, such a code would not be complete with a declaration that these are worthy objectives and an exhortation to work hard to achieve them. The formulated code should attempt to set forth in detail those conditions—including social arrangements and standards of individual behavior—that must be respected if these goals are to be achieved. The code would be based on an analysis of those relations among men that must be established and accepted if in the total processes of society, the special concerns of the engineering profession are to receive their due attention.

DIFFERENT POINTS OF VIEW

At this juncture, however, we encounter the most difficult problem of all. If each profession works for its own special aims, and orders its standards of conduct so that these aims will be advanced, what happens when the aims of the different callings come into conflict? There is and can be no easy solution for this problem. Only a phrase can be offered which perhaps conceals more difficulties than it solves. That phrase is: "enlightened and tolerant partisanship."

The profoundest aspect of our democratic system does not

lie in the simple device of majority vote, but in the fact that the decisions which shape men's lives are arrived at by a procedure that involves the participation of men representing different interests and different points of view. The decisions of a corporation, for example, will enter usefully and effectively into men's lives and thoughts only if they represent the merging of divergent special concerns where there has been consultation with those who are concerned for dividends, with those whose special interest it is to keep technological progress alive, and with those whose province it is to see that the employees work under dignified and satisfactory conditions.

The representation of a special point of view can only be effective if it is in some degree *partisan* or, to use a harsher expression, *biased*. In the total processes of society the engineer, lawyer, physician, military expert, and the scholar must each pull his oar, but to pull it effectively he must act to some extent as if it were the only oar, as if it were through his efforts alone that the ship of state moved forward. This is what is meant by partisanship. But if partisanship is not to result in a sterile deadlock, it must also be enlightened and tolerant.

What each profession must do is, then, a very difficult thing. It must be diligent and faithful in its own mission and yet recognize that there are other missions rightfully claiming an equal diligence and fidelity of those who are dedicated to them. Plainly there is demanded here a delicate and precarious balance. Yet the mainspring of our own system lies precisely in that balance. For the hidden weakness of totalitarianism (as well as its most obvious appeal) is that it ignores the necessity for this balance, pretending that all the forces of society can be channeled without internal tensions toward goals imposed from above. The essence of social morality and the strength of our own system lie, not in imagining problems out of existence, but in recognizing them for what they are and in marshalling our best efforts to solve them as well as we can within the limits of our own capacities.

ENGINEER'S ROLE

In conclusion, perhaps the meaning of what has been called "enlightened and tolerant partisanship" may be illustrated by referring to one of the special concerns of the engineer. The engineer's role in maintaining the integrity and efficiency of the productive process may seem so obvious a goal as not to require special representation by any profession. Yet operating a factory, or conducting any other industrial activity is complex and it is easy to lose sight of the purpose of the enterprise. One recalls in this connection how at the end of a long conference devoted to labor relations or to a proposed advertising campaign, someone, usually an engineer by training, will be heard to say in a tone of weariness and frustration, "Well, this is not producing goods." It is very important that someone should keep clearly in mind that the aim of a factory is to produce goods. At the same time the engineer must be aware of the hidden subtleties of his mission and of its relationship to that of other callings. He should remember that the very concept of "production" cannot itself be defined in engineering terms. One can apply engineering techniques to make men unhappy as well as to make them happy, as indeed we do in time of war. One may work industriously to distort sound, not to reproduce it faithfully, to put coal in the ground, rather than to take it out. Production cannot be understood except in terms that include the elusive concepts of human satisfaction and human development. When the engineer keeps this fact in mind, he is able to give effective and, in a proper sense, partisan representation to society's interest in production without losing sight of the interaction of this special aim with those of other professions.

Outdoor Compressor for High-Speed Motor

An outdoor 43,200 cubic feet per minute American Blower centrifugal compressor, direct-coupled to an ACEC Electric Corporation 1,250 hp, 3,600 rpm electric motor, has been installed in the Petrofina refinery at Pointe Aux Trembles, Quebec, Canada. The compressor will serve as a combination air ift and combustion blower for the refinery's 16,000 barrel-a-day Houdriflow catalytic cracking unit.

Operating on 3-phase 60-cycle current at 4,160 volts, the ACEC motor that drives the compressor is a 2-pole squirrel-cage induction unit, cooled by forced ventilation, and lubricated by a pressure-feed system. Constructed of forged steel to withstand strong centrifugal stresses, the rotor is statically and dynamically balanced for vibration-free rotation at high speeds.

The compressor and motor are designed for around-the-clock operation. Because of the outdoor location, the motor is equipped with special heating facilities to prevent moisture condensation during cold weather shutdowns.

New Circuits for Recurrent Surge Oscillography

D. D. DAVIS

This new transient analyzer, a combined recurrent surge generator and oscillograph, has many new circuits to increase the convenience and accuracy of transient response measurement. A 400-cycle surge generator gives intense images. A vertical-bias system on the cathode-ray tube provides unmetered bias for positioning, metered bias for displacement-type deflection measuring, and astigmatism control for measuring small differences of large voltages. A time-measuring circuit provides two blank spots on the sweep whose positions are adjustable and metered.

A TRANSIENT ANALYZER[1,2,3] is essentially a versatile low-voltage repetitive-impulse generator and a cathode-ray oscillograph. It will generate transient voltages of a wide variety of shapes and durations. Unidirectional waves with front times of 0.1 to 100 microseconds (μsec) and tail times of 0.1 to 1,000 μsec as well as bidirectional and damped oscillatory waves can be generated. The amplitude of these transients can generally be varied from about 100 to 1,500 volts. These low-voltage transients can be applied to networks, windings, transmission lines, amplifiers, and other devices without fear of damaging insulation. Once the transient is applied to a network, the resulting transient voltage appearing at any point in the network can be determined by displaying this transient voltage on the screen of the cathode-ray tube contained in the transient analyzer. The resulting image can be measured quite accurately in both magnitude and time, and when it is desirable it can be recorded on photographic film for future study.

CIRCUITS

THE BASIC CIRCUIT of the transient analyzer is shown in Fig. 1. A source of alternating voltage charges a capacitor, C_g, through a rectifier during one-half cycle. During the other half cycle, the triggering device sends a pulse through the time-delay circuit and fires the thyratron, and the capacitor, C_g, discharges through the pulse shaping impedance Z, into the network whose transient response is to be measured.

Radar systems use d-c supplies for charging, but will function only when the current in the surge reverses before the charging part of the cycle. Since many surges are not of this nature in transient analysis work, a-c charging is quite desirable, and adds considerable flexibility to the surge generator.

The vertical deflection system of an oscillograph is used to measure the voltage between any two points in the network. The trigger pulse which ignites the thyratron also initiates the time base in the oscillograph whose sweep length may be varied from 0.5 to 5,000 μsec. Thus, a plot of voltage vs. time is repetitively presented on the oscillograph over a wide range of sweep times and between any desired points.

A more detailed block diagram of the transient analyzer is shown in Fig. 2. A 400-cps electronic power source V_{1-4} or 60-cps line power charges C_g through the rectifier, V_5, during the first half of each cycle. At the beginning of the next half of each cycle, phase shifted voltage from the desired power source excites an electronic peaking circuit V_6, and fires the thyratron trigger pulse generator, V_7. The resulting trigger pulse passes through an inductance-capacitance delay circuit and triggers the pulse-generator thyratron, after the desired time delay. C_g then discharges through the thyratron, the pulse shaping impedance Z, and into the network whose response is to be measured. A chopper, V_{10}, is available for placing a short circuit across the network at any desired time. A diode, V_9, handles any reverse current which tends to flow through the thyratron V_8. The voltage across any two points in the network is attenuated by a capacitance divider and applied to the vertical deflection plates of the cathode-ray tube. A second and smaller pulse from the thyratron trigger pulse generator triggers the multivibrator circuit, V_{11-13}, whose output is repetitive negative square waves of 0.5 to 5,000 μsec duration. These negative square waves in turn drive a sweep circuit V_{14-18}, which applies balanced triangular waves of 0.5 to 5,000 μsec duration to the horizontal plates of the cathode-ray tube. The negative square waves also drive an unblanking circuit, V_{19}, which applies positive square waves to the control grid of the cathode-ray

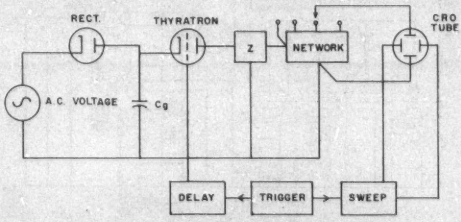

Fig. 1. Block diagram of transient analyzer

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The author wishes to acknowledge the ideas contributed by J. G. Anderson and the encouragement and direction of J. H. Hagenguth.

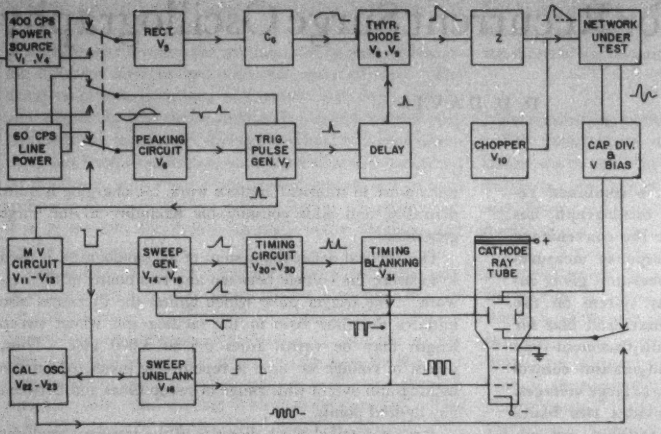

Fig. 2. Detailed block diagram of the transient analyzer

tube for the duration of the sweeps and turns on the cathode-ray beam. An output of the sweep circuit also drives the timing pulse circuit, V_{20-30}, which generates two positive pips at controlled times on the sweep. These two pips are applied to the timing pulse blanking tube V_{31}, which is in parallel with the unblanking tube and turns the beam off at the controlled times on the sweeps, making time markers. The negative square waves are also used to turn on the calibration oscillator, V_{22-23}, during the sweeps. The oscillator may be connected to a vertical deflection plate to calibrate sweep rate.

400-CYCLE SURGE GENERATOR

One need in recurrent surge oscillography is a surge generator which will function at a high repetition rate and at a high power level. Without a high repetition rate the intensity of the trace on the cathode-ray tube becomes very low as the sweep time is shortened, especially below 2 μsec. For these reasons a 400-cycle power source in addition to the regular 60-cycle line power has been selected for charging and discharging C_g.

This 400-cycle power is obtained from an oscillator and amplifier as shown in Fig. 3. The oscillator uses push-pull *6F6* tubes, V_{1-2}, with transformer feedback and gives stable harmonic free output of 300 volts peak amplitude.

The a-c plate voltage for the *2D21* trigger thyratron, V_7 is supplied directly from the oscillator. Sharp positive pulses for firing the grid just after each charging cycle are obtained by shifting the phase of the oscillator voltage and then clipping, amplifying, and differentiating twice. The oscillator also drives the push-pull class *B* power amplifier using *809* tubes, V_{3-4}. The output of the power amplifier is attenuated by a potentiometer and charges the generator capacitor, C_g, through an *866* rectifier tube, V_5.

The pulse from the *2D21* goes through a variable inductance-capacitance delay circuit and is used to trigger the *FG105* thyratron which discharges C_g through the pulse shaping impedance into the sample under test. The pulse from the *2D21* also goes through an attenuator, cathode follower, and a 1/2-μsec delay line and triggers the oscillograph sweep circuit.

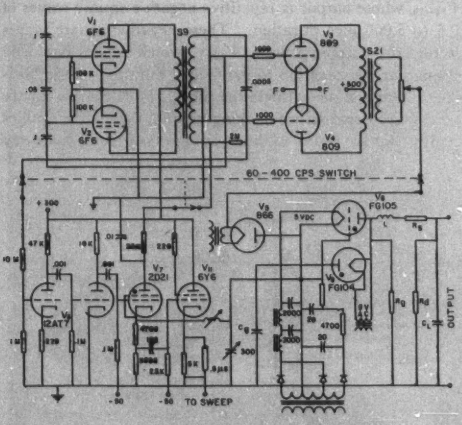

Fig. 3. 400-cycle supply and surge generator

VERTICAL BIAS SYSTEM

Measurement of amplitude on the face of a cathode-ray tube may be done in several ways, comparison with scribed cross-sectional lines on a lucite screen being the most common method. This has the advantage of simplicity, but fails to compensate for barrel and pincushion distortion, and for nonlinear response of the deflection system. In addition, answers are obtained in inches which frequently must be converted into volts. Another method, the image displacement system, has been used in oscillographs for many years, but its use has generally not been made convenient to the user.

The displacement system can be made quite convenient

if an unmetered positioning control is provided. This control is used to align the zero reference point of the trace to be measured with a horizontal reference line drawn on the screen. See Fig. 4. The metered positioning control is then used to align the point on the trace to be measured with the reference line drawn on the screen. The voltage required to displace the image is equal to the deflection voltage and may be read directly from a panel meter.

Referring to Fig. 5, the unmetered positioning control R_1, adjusts the bias voltage on one deflection plate. The metered positioning control, R_3, controls the bias voltage on the other deflection plate and is metered by a 20,000 ohms-per-volt voltmeter.

Another aspect of the vertical-bias system is astigmatism control.[4] When measuring a small difference, 50 volts, between two large voltages—450 and 500 volts—as one might find between adjacent coils on an inductance, severe astigmatic defocusing is encountered. It is caused by lack of symmetry of the electric field as the electrons pass through the deflection plates. Making the vertical deflection voltage as well as the horizontal deflection voltage balanced with respect to ground will eliminate this astigmatic defocusing.

This condition may be met for any desired portion of the image by the application of an adjustable direct voltage from R_3 to both vertical deflection plates through the 500-megohm return resistors, see Fig. 5. In a majority of applications a surprisingly large part of the image may be refocused. If accurate measurements are to be made between portions of the wave which are not simultaneously in focus, it may be done by correcting the astigmatism for each portion when recording or adjusting its position.

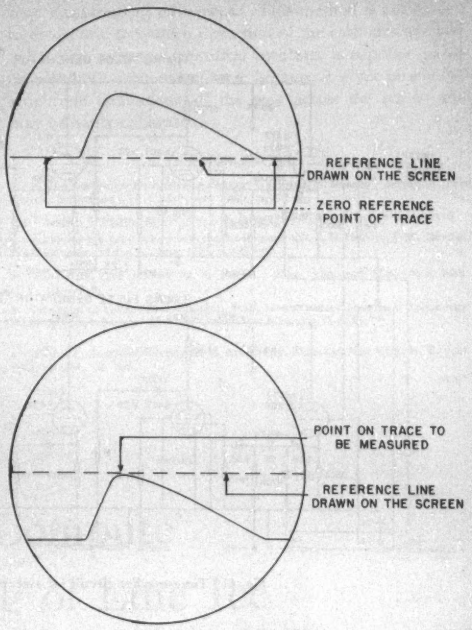

Fig. 4. Vertical-bias circuit

TIME MARKERS

Measurement of time on the face of a cathode-ray oscillograph is generally accomplished by applying a shock-excited oscillator to the vertical deflection system and calibrating the screen. This is a laborious process and gives inaccuracies when there is barrel or pincushion distortion. The time-measuring circuit on this oscillograph provides two blank spots on the sweep whose positions are adjustable and metered as percentage of sweep time. By adjusting these spots to different points on the wave under observation, the time between any two points on a wave may be determined. The circuit used is shown in Fig. 6. The sweep voltage is applied to two cathode followers, whose output is applied to two diodes. The "Mark I" and "Mark II" positioning controls, R_2 and R_4, apply a bias to these two diodes, the difference in bias being applied to the voltmeter M.

The calibration is such that the percentage reading on the voltmeter is equal to the difference of the bias voltages divided by the total sweep voltage, when the sweep voltage from the cathode followers exceeds the bias voltages, the diodes *D21* and *D26* become conducting, and the diodes *D22* and *D27* become nonconducting, sending a positive going pulse through the right hand set of diodes to the *6AC7* amplifier tubes. The diodes *D34* and *D35* prevent the *6AC7*'s, V_{23}, and V_{28}, from being driven positive. The *6AC7* amplifier tubes V_{23} and V_{28} give a negative output pulse having a rise time of about 3 per cent of the sweep time. These pulses are then fed through 1/2 *12AT7* cathode followers V_{24a} and V_{24b} which present a high impedance to the output of the amplifiers and a low impedance to the following stage. The outputs of the cathode followers are fed into two *6AG7* pulse generating stages, V_{25} and V_{29}, driving the control grids from saturation to cutoff. The plate current suddenly stops and the inductance-capacitance circuit in the plate lead oscillates due to shock excitation. After one half cycle of oscillation, the germanium diodes, D_{33} and D_{37}, become conducting and damp out all the following oscillations, leaving single positive pips as the outputs. The duration of the pips is varied, being made proportional to the duration of the sweep being used. These pulses are fed into a *12AT7* cathode follower—mixer stage, V_{30}, which puts both pulses on one channel and drives the *6AH6* blanking tube, V_{31}.

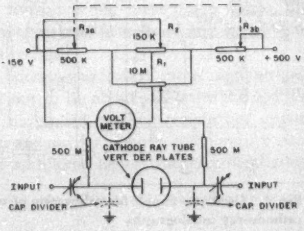

Fig. 5. Vertical-bias circuit for cathode-ray oscillographs

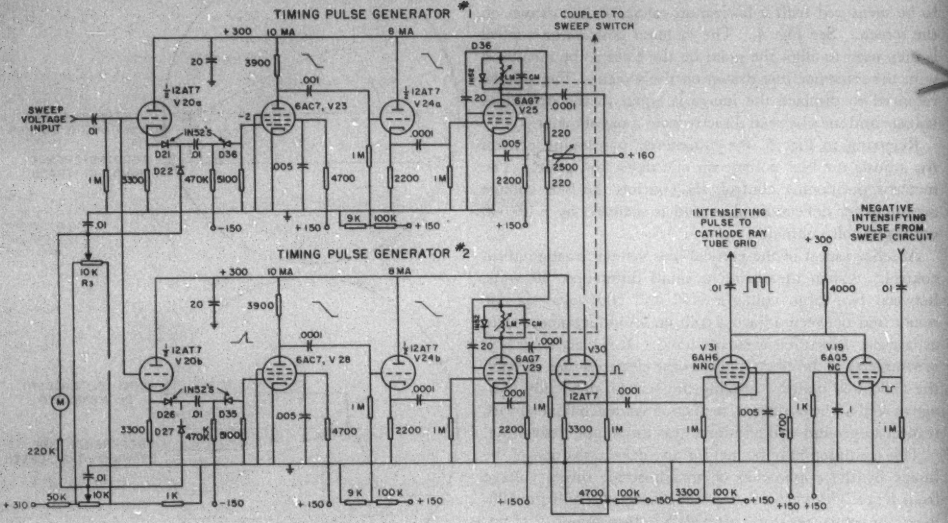
TIMING PULSE GENERATOR #1
COUPLED TO SWEEP SWITCH
SWEEP VOLTAGE INPUT
TIMING PULSE GENERATOR #2
INTENSIFYING PULSE TO CATHODE RAY TUBE GRID
NEGATIVE INTENSIFYING PULSE FROM SWEEP CIRCUIT

Fig. 6. Time-marker circuit for sweep systems on cathode-ray oscillographs

The plate of the *6AH6* is in parallel with the plate of the unblanking tube, resulting in two blank spots on the screen corresponding to the percentage rotation of the Mark I and Mark II controls.

OSCILLATOR

SHOCK-EXCITED OSCILLATORS are commonly used for the calibration of repetitive sweeps. However, it is rather difficult to calibrate the frequency of the shock-excited oscillator. An indirect method involving appreciable error is generally used. The oscillator in this transient analyzer is a transitron oscillator[5,6] which is switched on at the beginning of each sweep and turned off at the end of each sweep. It may also be switched on so that it will be a free-running oscillator and may be directly calibrated with very little error in this mode of operation.

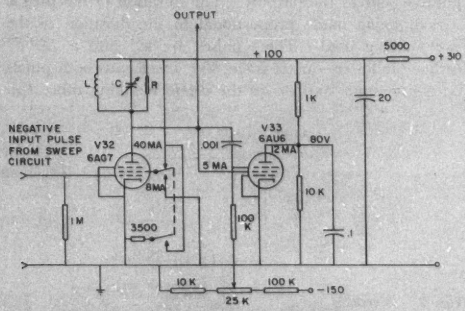

Fig. 7. Oscillator circuit for calibration of repetitive time bases in cathode-ray oscillographs

The details of the circuit are shown in Fig. 7. A *6AG7* switch tube V_{32} normally conducts a heavy current and provides a positive resistance which overcomes the negative resistance of the *6AU6* transitron oscillator, V_{33}. At the beginning of the sweep, the grid of V_{32} is driven from saturation to cutoff, resulting in shock-excited oscillation of the inductance-capacitance circuits in its plate circuit and also removal of the positive resistance of V_{33}. With removal of this positive resistance, the negative resistance tube V_{33}, overcomes most of the positive resistance in the inductance-capacitance circuit and allows it to oscillate with very little damping. Output is obtained from the V_{32} plate end of the inductance-capacitance circuit. At the end of the sweep, V_{32} is again driven to saturation and its positive resistance overcomes the negative resistance of the V_{33} transitron circuit, damping all oscillations in the inductance-capacitance circuit until the next sweep. The values of inductance and capacitance are switched for various calibration frequencies, resistors being added across some of them so that the Q of all the combinations will be equal. The inductance-capacitance ratios must be high enough to assure proper starting of the oscillations. For calibration, the screen voltage is removed from V_{33}, eliminating its positive resistance. The negative resistance of V_{33} then overcomes the positive resistance of the inductance-capacitance circuit. This provides operation as a free-running transitron oscillator. A potentiometer control is provided to adjust the negative resistance of V_{33} and may need to be readjusted to allow oscillations for calibration purposes.

An off position on the frequency selector switch substitutes a resistor for an inductance-capacitance circuit and stops it from operating erratically when it is not connected to the cathode-ray plates.

CONCLUSIONS

1. The use of a surge generator operating at 400 cps gives a considerable increase in the intensity of waves observed on the oscillograph, especially on sweeps shorter than 10 μsec.
2. Displacement measurement of displayed waveshapes compensates for inaccuracies in cathode-ray tube patterns and gives measurements directly in volts.
3. Astigmatism control allows measurements to be made when observing a small difference between large voltages.
4. Controlled time markers are a convenient method of time measurement on sweeps. This method is not subject to errors due to pattern distortion of the cathode-ray tube.
5. The switched transitron oscillator is superior to the simple shock-excited oscillator because it gives nearly full amplitude oscillations all the way across the screen and may be easily calibrated.

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How to Compute the Thawing of Line Ice

C. H. SPADERNA

Formulas are derived for more accurately computing the thawing of line ice. Experiments which were conducted to determine the various heat losses to increase understanding and control of the thawing process are described.

MANY UTILITIES use their own formula to compute the electric energy for thawing of line ice. The formulas are based on speculation and assumptions rather than on experiment. Accuracy within 10 per cent is considered rather good. D. C. Stewart[1] developed diagrams, considering heat transfer through the ice coat of a conductor, convection by a wind perpendicular to the conductor, and melting of a slot through the ice top, allowing the conductor to creep out. Heat radiation, wind direction other than perpendicular, snowfall, and the actual amount of ice melting were not taken into account.

These components appear in new formulas presented here. The various heat losses were analyzed by experiment. This may help to better understand and control the thawing process. Total results are closer to measured energy than results obtained from published formulas.

EXPERIMENTS

FAIRLY EVEN ICE COATS were produced on an aerial conductor by spraying tap water over it through a nozzle. Preliminary tests with icicles, or with icicles removed, showed even long icicles cause but negligible heat loss. Therefore, icicles did not enter into the calculation of thawing.

Ice, falling off the line after a melting period, was weighed and its volume computed. Thus, the share of melted ice in the original ice coat was determined for different thawing times.

Well established thermodynamic constants for ice melting and heat radiation from metals allowed the setting aside of melting and radiation heat. Heat was expressed in kilowatthours per square foot of conductor envelope surface. Radiation was computed after Stephan-Boltzmann, assuming zero C surface temperature.

Thawing energy was compared in still air and in wind. The natural air flow around the conductor, caused by its temperature differences, was stopped in some tests by a board shield. Thus, convection heat losses were the difference in energy with tests in still air and in wind of various speed and direction.

The rest of the energy was called metal and air-gap heating. It turned out to be about ten times the specific heat of the metals, multiplied by their weight per square foot conductor surface, and by degrees temperature rise. Snowfall carried off additional heat. Inches precipitation

A special article recommended for publication by the AIEE Committee on Transmission and Distribution.

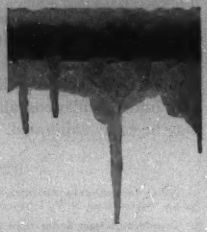

Fig. 1 (left). Extremely uneven ice coat on a special test cable.
Fig. 2 (right). Close-up view during the melting process

of snow per hour were found by conversion of the snow into water.

FORMULAS

THE THAWING ENERGY for copper conductors is: $C=z\times 0.0000442\times u$ (for metal and air gap heating)$+0.0205\times h$ (for radiation of heat)$+(0.004+0.00014\times v)\times h\times u$ (for heat convection by air)$+k\times i$ (for melting of ice)$+0.28\times n\times h\times u$ (for heat, carried away by snow) (1)

Equation 1 may be simplified by neglecting the first and last share: $C'=h\times[0.0205+(0.004+0.00014\times v)\times u]+k\times i$ (2)

With steel-reinforced aluminum cable or aluminum overhead cable the thawing energy is: $S=(a\times 0.00102+s\times 0.000489)\times u$ (for metal and air gap heating)$+0.002\times h$ (for heat radiation)$+(0.004+0.00014\times v)\times h\times u$ (for heat convection by air)$+k\times i$ (for melting of ice)$+0.28\times n\times h\times u$ (for heat, carried off by snow) (3)

Explanation of Symbols. C, C', S=energy in kwhr/sq. ft. conductor surface; z=pounds of copper/sq. ft.; a=pounds of aluminum/sq. ft.; s=pounds of steel core/sq. ft.; with no steel core: $s=0$, u=degrees centigrade below zero of ambient air; h=hours of thawing; i=mean radial thickness of ice coat in inches; v=velocity in mph of a wind, entered in full, if perpendicular to the line; with a wind, blowing parallel to the line, measured v has to be replaced by 0.75 v; for angles between 0 and 90° the factor of v may be interpolated; n=inches precipitation of snow per hour. Values of k are compiled in Table I. Other values may be interpolated.

Table I. Melting Constants k for Various Thawing Times.

Thawing Time, min	Thawing Time, hr	Melting Constant k
≧50	≧0.835	0.06575
40	0.667	0.0667
30	0.5	0.0778
20	0.333	0.0818
≦10	≦0.167	0.0828

Observations in the Field. To obtain wind data in the field, one measurement is never enough as it may catch either a gust or a lull. Mean ice thickness is best determined by taking off the icicles and then the ice coat on a measured length of line. The gathered pieces of the ice coat are weighed and, after finding the specific gravity, thickness is computed.

In Fig. 1, it can clearly be seen that the armor of ice is not coaxial with the conductor. The water droplets were pushed aside by a wind before freezing. As soon as a thin air gap is melted out of the ice around the conductor the ice coat breaks apart. Wind causes vibration and twisting, throwing off the remaining ice. When the ice is forced down fast by a large current there is less help from mechanical action but convection and radiation are reduced as well. Thermocouple measurements showed sunshine has a negligible influence.

CONCLUSIONS

1. From loss analysis it follows that quick thawing (small h in equations 1 through 3) is most economical.
2. Even with incomplete weather data furnished, new formulas 1 through 3 give more accurate results than hitherto known formulas as set forth in the following examples.

EXAMPLES

1. Copper conductor no. 3, $u=-11$ C, $v=35$ mph, $i=1/4$ inch, $h=0.167$ (=10 min), $z=0.245$ pounds/sq ft From equation 1: $C=0.04057$ kwhr/sq ft, with 641 sq ft/mile. . . 26.0 kwhr/mile. From equation 2: 25.9 kwhr/mile, including 13.25 kwhr/mile for melting. Measured: 26.3 kwhr/mile. D. C. Stewart's diagrams yield: for convection and heating 0.167 hr×20 F×3.8 kw/mile; F=12.7 kwhr/mile; for melting 0.167 hr×0.25 inch×310 kw/mile=12.8 kwhr/mile. Total: 25.5 kwhr/mile.

2. Same wire: $u=-2$ C, $v=10$ mph, $i=1/4$ inch, $h=0.167$ (=10 min)[2]. Equation 1 gives: $C=0.0259$ kwhr/sq ft or 16.6 kwhr/mile. Measured: 16.0 kwhr/mile. After Stewart: 14.2 kwhr/mile, 11 per cent less than measured.

3. Same wire: $u=-2$ C; $v=10$ mph, $i=1/4$ inch, $h=0.055$(=3.3 min)[2]. From equation 1: $C=0.02248$ kwhr/sq ft or 14.4 kwhr/mile. 92 per cent of energy is spent for melting. Measured 900.0 amperes or 14.1 kwhr/mile.

4. From a 300-thousand-circular-mil copper cable[1] 1/2 inch of ice was thawed off in 0.6 hr at 20 F air temperature and $v=16$ mph. Wind direction not stated. From equation 1: $C=0.0878$ kwhr/sq ft, corresponding with 808.0 amperes. Measured: 750 amperes. Stewart himself computed 684 amperes. From a nonperpendicular wind a substantially smaller current would follow. For wind parallel to the line, $I=795$ amperes.

5. From a 4/0 steel-reinforced aluminum cable 1/2 inch of ice was thawed in 1.9 hr by 350 amperes (1). Weather data: $u=20$ F, $v=20$ mph.

Equation 3 gives: $S=0.137$ kwhr/sq ft, demanding 356.0 amperes, Stewart found 363 amperes.

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Tests on 138-Kv High-Speed Oil Circuit Breaker

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WHAT is believed to be the heaviest fault interruption ever made at 138 kv was attained during field tests on July 3, 1954, at the 600-megawatt Philip Sporn Power Plant of American Gas and Electric Company when a 138-kv 1,200-ampere (amp) 5,000-megavolt-ampere (mva) 3-cycle oil circuit breaker of standard design (Fig. 1) interrupted 6,900 mva under normal tripping conditions; that is, pretripping was not resorted to for obtaining a large numerical value of power. Asymmetry for this interruption was 49.5 per cent. The breaker interrupted all power available at the site, including that received from distant stations as shown in Fig. 2. A comparison of the 6,900-mva value with the 3,500 mva interrupted 10 years ago at Philo Station points to the rapid growth of the system.[1]

Thirty-one fault tests were made covering conditions of maximum severity for the various kinds of short-circuit conditions of the system, including multiple reclosing. Results showed that transformer breakers interrupting to 1,000 mva are subjected to transient voltage crests up to 250 per cent of normal crest with recovery rates to 3,600 volts per microsecond, but that these values can be greatly reduced by suitable shunt resistors across interrupters. Also, it was shown that current through a transformer breaker may not reach zero for several cycles after inception of a fully offset fault, indicating the desirability of slightly delaying tripping to avoid possible damage to the breaker.

Transmission-line circuit breakers at high-current faults, 3-phase ungrounded and 1-phase grounded, had crest voltage to 160 per cent of normal crest-to-ground, with recovery rates from 500 to 1,000 volts per microsecond.

Fault-interrupting times were well within 3 cycles except that 3.4 cycles was the maximum for the low-current tests, still well within rating per American Standards Association standards.

Fig. 1. Test circuit breaker

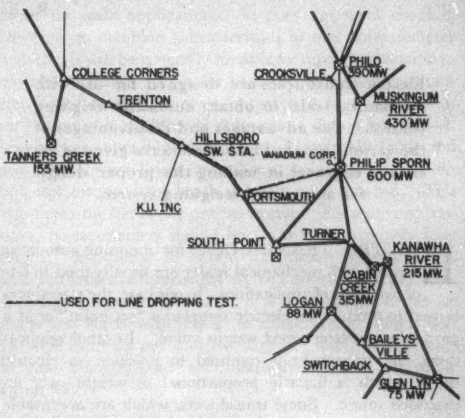

Fig. 2. Simplified diagram of the 138-kv system showing principal lines and connected generating capacity

Fourteen line-dropping tests were made on a 58-mile line and 12 on a 157-mile line, with charging currents of 25 amp and 72 amp, respectively. One pole of the breaker had four of its six interrupters shunted with low-ohmic resistors designed also for capacitance voltage division. No restrikes occurred at the pole having resistors. Occasional restrikes at poles, not so equipped, resulted in maximum voltage of 236 per cent of normal crest. Interrupting times for the 157-mile line drops averaged 1.77 cycles without resistors and 3.13 cycles with resistors, including time for interrupting the smaller resistor current.

Efficiency of instrumentation and preplanning enabled the entire test program to be completed on two Saturdays and one Sunday. No contact dressing or replacements were made or required during the tests. On completion, the contacts and interrupters were estimated to be in sufficiently good condition so that further interrupting duty would be possible before servicing.

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Electric Transducers for Automatic Weighing

R. E. BELL

Electric transducers are designed for use with mechanical scales to obtain automatic weighing control. The advantages and disadvantages of the various types of transducers are given to assist the engineer in making the proper design for any special weighing system.

ELECTRIC TRANSDUCERS for obtaining automatic control with mechanical scales are usually used in one of two types of applications. In one case, the transducer is used to produce an electric signal at a "set point" or at a particular predetermined weight value. In other applications, the transducer is required to produce an electric signal which is linearly proportional to weight over an extended range. Some transducers, which are acceptable for set-point applications, are not suitable for proportional applications which require a high degree of linearity.

To help in understanding these two classes of applications, certain characteristics required for each are listed and discussed. Requirements for both set-point and proportional applications are: (1) negligible scale-loading effect; (2) high resolutions; and (3) stability with respect to line voltage and temperature variations. Additional requirements for proportional applications are: (4) linearity; and (5) phase stability.

The traditional high-accuracy levels (better than 0.1 of 1 per cent) attained by automatic and beam-type force balance scales have been made possible by reducing friction in the scale mechanisms to the barest minimum. If this accuracy is to be preserved when electric controls are added to scales, the transducers used must not produce appreciable drag on the scale mechanism. At the indicator shaft of a typical scale, a force in the range of 0.01 to 0.05 inch-ounces will produce an error of one graduation.

The requirement for high resolution is also related to overall accuracy. To determine a set point to the required accuracy may necessitate sensing motions in the order of 0.010 inch.

Probably the most significant factor in limiting the performance of electric controls in scale systems has been drift caused by changes in line voltage and temperature. Accuracy figures are sometimes quoted which make no allowance for these drifts. Such practices are unrealistic for industrial applications, where line voltage and temperature changes are the rule rather than the exception.

For a measuring device to be accurate, it does not necessarily have to have an indication or control action which is linearly proportional to the input variable. Accuracy can be obtained by individually calibrating each model of the device. The cost of such measuring instruments would be prohibitive for most industrial applications.

The practical approach is to make the device linear and to calibrate it at only a few points in its range. In the better dial-type scales, it is possible to set the indication "right on" at five points on the dial.

When a-c-type electric transducers are used for control, it is often desirable to add or subtract their electric output signals. If the output voltages differ in phase, null voltages occur in bridge balancing circuits which reduce the resolution of the system and therefore the accuracy. Fixed phase shifts can be compensated easily in the electric circuitry, but if the phase varies with the input control action or line voltage or temperature, about the only cure is to use discriminators or choppers in the bridge balancing circuits.

Electrical transducers which would probably be considered for application to scales are: (1) linear differential transformers; (2) synchros; (3) potentiometers; (4) strain gauges; and for strictly set-point applications are: (5) magnetic mercury switches; and (6) photoelectric cutoffs.

The advantages and disadvantages of each of these types of transducers will now be discussed.

Linear Differential Transformers. In many ways the linear differential transformer is about the most universal transducer available for industrial applications. It can be used for set-point or proportional applications.

If primary excitation voltage is not excessive (usually under 10 volts), the magnetic reaction forces will not adversely affect scale operation. The core or plunger should be mounted on the scale so that the core does not touch the coil form, or low-friction guides should be used to center the core in the coil. If guides are used the coil and core assembly should be mounted with a vertical axis of motion to avoid the added friction which would result from gravitational pull.

Standard commercial units are available which can be used in matched pairs to obtain sufficient linearity for many purposes. In scale applications, however, some circuit adjustments or trimming of transformers is necessary to obtain a linearity of 0.1 of 1 per cent. This statement is particularly true if the linear motion of the indicator drive rack is used to drive the transformer. This motion is about 2 inches, so a long stroke transformer must be used. The longer the stroke of a linear differential transformer, the more difficult it is to make it linear.

Linear differential transformers may be actuated by other

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motions in the scale than that of the indicator drive rack. For example, they may be attached to the tare beam lever. The motion of the tare beam lever is not linear, however, but follows a known arcuate curve. Correction for this curvature may be introduced by simple linkages.

Certain precautions must be taken to make linear differential transformers completely satisfactory from the stability viewpoint. They tend to exhibit line voltage and temperature instability effects. These effects can be made negligible by proper design of the transformers themselves and by proper choice of circuitry.

The principle factor determining stability in the transformers themselves is uniformity. The more nearly identical the units are in a pair of transformers used in a bridge, the more stable they are with respect to line-voltage and temperature changes. Temperature stability can also be increased by connecting primary windings in series or by exciting them through a stable series resistor.

Synchros. Synchros have certain advantages in some scale applications. Where only remote indication is required, and where rotary motion is available, they excel. They are capable of high resolution, good stability with respect to line voltage and temperature, and can be made to have sufficiently low mechanical loading on the scale.

They do have certain disadvantages when control is needed. They can only be used effectively in pairs. The output voltage from a single synchro cannot readily be combined with other signals to produce control information.

Another limitation in control application is that synchro pairs can produce control action, which is ambiguous in its direction of rotation. If one synchro in a servo-control application is displaced more than 180° with respect to the other, the command signal from the pair will be of such a phase as to increase the error rather than decrease it. This factor is not important if the synchro system is used only for indication and there are no mechanical stops. It can cause improper sequencing in control systems where the remote synchro can be returned to a lower value by first going through all higher values.

Many commercially available synchros will tend to load the scale excessively. Units can be obtained with sufficiently low-frictional torque levels if they are properly specified. The torque figures given previously can be used for this purpose.

Power synchros or self-synchronous systems provide a simple means for obtaining remote indication. Remote control can also be obtained if the control devices are of such a nature as to not load the system.

Certain precautions must be taken in using self-synchronous devices to avoid errors. In this application relatively high voltages are used on the synchro windings. This results in large values of flux in the air gaps, which can produce magnetic loading on the scale. Usually this reaction is in the form of "cogging". To avoid this effect, the minimum excitation voltage consistent with accurate tracking should be used. It may be desirable to modify the brush structure in the heavier duty types of self-synchronous devices to reduce friction. It should be noted that when a self-synchronous system is used to repeat a dial indication, the loading of both dials is reflected into the scale mechanism. This means that the remote indicating or control device must be as free of friction or other restrictive forces as the scale itself.

Potentiometers. Potentiometers are presently available which meet some of the requirements of an electric transducer for scale applications. It does not seem possible, however, to combine characteristics in one potentiometer such that it will be generally suitable for direct application to mechanical scales. In order to make a 1-turn potentiometer linear enough for scale purposes, it is usually necessary to make it too large in diameter to obtain low torque. Low-torque potentiometers are small diameter types and are therefore not linear enough for the purpose. To obtain low torque, light brush pressure must be used. This also limits the life of the potentiometer. For scale applications, potentiometers should be capable of extremely long life. It is possible to obtain low-torque potentiometers with linearities of approximately one quarter of 1 per cent. If the proper wire is used in a potentiometer, it can be made very stable with respect to temperature. Since their variable elements are resistive, they are stable with respect to line voltage, and are relatively immune to phase variation.

Cutoff Devices. Two other devices which are commonly used to determine set points in the scale operation will be discussed briefly. The magnetic mercury switch provides about the lowest cost type of cutoff generally available for the purpose. It provides a simple circuitry with very little auxiliary apparatus. It does, however, have a tendency to load the scale by magnetic reaction and thereby cause errors.

Photoelectric pick-off devices have been used extensively in automatic weighing. They are capable of accurate location of cutoff points and do not impair the accuracy of the scale in any way. The principle disadvantage of this type of cutoff is its lack of flexibility.

Strain Gauges. The strain gauge, while obviously an electric transducer, should really be treated in a separate category from the others mentioned so far. In general, the afore-mentioned transducers can be applied to mechanical scales of the pendulum or beam balance type. This is not true of the resistance strain gauge. It is impractical to separate the displacement measuring element from the counter-force element in applying strain gauges to weighing applications. As a result, strain gauges are generally used only as components in the form of load cells.

For this reason, an appraisal of load-cell weighing is made on a system basis rather than on a component basis. A number of the advantages of load-cell weighing are as follows:

1. Simplicity of Load-Supporting Structures. The load to be weighed can be supported on strain-gauge load cells with a relatively simple structure compared with a lever system, because of load-cells small size and rigid structure. Tanks or platforms can be mounted directly on load cells with very little framing in most cases. Where side thrusts are

involved, simple struts can stabilize the structure without interfering with the small vertical motion necessary for weighing. This motion amounts to only a few thousandths of an inch.

2. Remote Location of Indicator. Remote indication of weight is easily obtained with a strain-gauge scale, since the weight information is transmitted through electric cables. The indicator can be placed in the most convenient location.

3. Corrosion Resistance. Load cells are hermetically sealed and are resistant to corrosive atmospheres. They are not subject to damage from abrasives and dust.

4. Low Maintenance. The load cells themselves should require practically no maintenance. This is of particular advantage where they are mounted in inaccessible locations. The indicating head will of course require the same type of maintenance necessary for other electronic devices. In general, it is expected that this will be more than that required for mechanical scales.

5. Flexibility. Having the weight information in electrical form in a strain-gauge scale makes it easy to adapt electric and electronic controls to them. For example, simple electric circuits using variable resistors can be used for setting cutoff points or for subtracting tare.

6. Reduced Installation Costs. The compactness of load cells permits their installation in platform scales with a minimum-sized pit. In tank scales, very little additional structure is needed for weighing.

7. Fast Response. The speed of response of a strain-gauge scale is primarily limited by the servo system used in the indicating head. In applications where speed is essential, high-performance servo systems can be supplied at extra cost.

Some of the disadvantages of load-cell weighing are as follows:

1. High Cost. Perhaps the most important limitation to strain-gauge weighing is the high cost of load cells. The precision type range in cost from about $400 to $700. Four load cells can easily cost more than a complete mechanical scale. The cost ratio for strain-gage scales is most favorable for very large capacities, where lever systems become expensive. Some of the additional cost of the load cells is offset by reduced installation costs. The electronic servo-type dial head costs several times as much as an automatic mechanical dial head.

2. Limited Accuracy. Precision strain-gauge load cells are now available whose output voltage is linear, with respect to an applied force, to within 0.1 of 1 per cent. A complete weighing system can be built using these cells which will have an initial accuracy approaching that of a standard industrial lever-type scale. Strain-gauge scales are subject to certain errors not present in pendulum or force balance-type mechanical scales. The strain-gauge scales use springs to provide restoring force and have, therefore, some of the weaknesses of spring scales. Their output will gradually change under sustained load caused by spring drift. Output for a particular load depends somewhat on whether load is being applied or removed. This characteristic is commonly called hysteresis. In addition to the mechanical drifts caused by the load cells, certain changes in indication can occur on account of electrical drifts. These can be minimized by careful attention to design details, but not completely eliminated. The electric drifts are aggravated by large changes in temperature at the indicator head or at the cells. Some of the drifts which occur on account of both electrical and mechanical variations can be eliminated by resetting the scale's zero adjustment. In some applications where scales are subject to corrosive or abrasive atmospheres or where there is vibration which will cause rapid knife-edge wear, the "in service" accuracy of a strain-gauge scale may be better than that of a mechanical scale.

3. Limited to High Capacities. Precision load cells are not presently available in capacities below 500 pounds. The operating principle of the bonded strain gage makes the design of low-capacity coils quite difficult.

4. Subject to Overload Damage. Load cells may be permanently damaged by overloads exceeding 50 per cent of their full capacity. In installations subject to shock loading, the cells must be protected with a shock absorbing platform or similar protective apparatus. In some cases, cells can be selected with a capacity in excess of that needed for static load to prevent overload damage, but this reduces their relative accuracy and makes them more subject to instrumentation errors.

5. Dead-Load Problem. Load cells are at a disadvantage where the ratio of the live load to be weighed is small compared to the dead load. Cells with capacity great enough to support all the load must be used, but only a small portion of their normal output will be available for operating the indicating apparatus. This leads to lower accuracy and higher drifts.

It would be desirable to summarize the foregoing analysis of electric transducers by picking out the one best unit for all weighing purposes but, as is often the case, no one type is best for all applications. It is hoped that the discussion of the advantages and disadvantages of each type will assist the design engineer in making a proper selection for his particular automatic weighing system.

Miniature Mercury Battery

"Tom's Thumb" or a dime is bigger than a new hearing aid mercury battery developed by General Dry Batteries, Inc., Cleveland, Ohio. Called the General *625*, this battery makes transistor hearing aids efficient and economical to use.

INSTITUTE ACTIVITIES

Pacific General Meeting Provides Subject Matter on Western Engineering Practices

THE PACIFIC GENERAL MEETING, held in Butte, Mont., August 15–17, 1955, provided a program of ten technical sessions, entertainment, and inspection trips in true Western tradition. The sessions started on time as C. H. Kirk and his vigilante committee rounded up stragglers by shooting blanks at their heels. The meeting was opened with a general session on Monday and, besides the ten technical sessions, an all-day meeting of the Board of Directors was held as well as several important committee meetings.

General Session

The feature of the General Session was an address, "The Year Ahead," by President M. D. Hooven. The main points of this concerned the growth of the electrical engineering profession and the large number of scientists and engineers from which the intellectual leadership of the next generation must come. One of the jobs that lies ahead is to see that all electrical engineering graduates become members of the organized profession. The work of Engineers Council for Professional Development (ECPD) and that of Engineers Joint Council (EJC) was discussed as well as the AIEE effort toward unity in co-operation with sister societies. In conclusion, President Hooven drew attention to the progress in the art and the important services which individual members can render in their own communities. Full text of the address appears on page 863–5 of this issue.

A brief history of mining operations in Butte, "Richest Hill on Earth," and the Anaconda properties were described by Arthur Linforth, assistant to the vice-president at Anaconda. The early history and plants of the Montana Power Company in relation to the importance of the engineer were described by W. W. German, manager of the Butte Division. The 70,000-kw Billings Steam Plant was the first semioutdoor plant installed that far north, and operation has been entirely satisfactory during severely cold temperatures. These talks served as excellent introductions to the inspection trips.

The meeting was opened by W. H. Mott, general chairman, and a cordial welcome was extended by Tim Sullivan, Mayor of Butte, and John R. Walker, vice-president of District 9.

Following the talks, the audience was entertained by the Virginia City Players who produce musical skits, some of which were typical of Western life in old mining days.

Student Branch Counselors Luncheon

The Student Branch Counselors of Districts 8 and 9 held a luncheon meeting with Professor L. R. Kersey, University of British Columbia, Vancouver, Canada, presiding.

After introductions of those present, W. B. Morton, chairman of the Student Branches Committee, talked to the counselors and expressed gratification at the fine showing by the number present. In a review of the Committee's work he said that a revised Student Branch Manual would be sent out this Fall and a careful reading was urged as there were many changes. In regard to finances, on request, each Branch will be sent $25.00 for operational expenses and it is planned to have the vice-presidents in each of the Districts visit the Student Branches during the year. The Student Branches Committee was set up with a number of subcommittees which were reviewed, and Chairman Morton urged the counselors to increase the interest of students in the Branches. Suggestions from the counselors were invited and these will be given serious consideration by the Student Branches Committee.

The business related to student activities and the reports of subcommittees at the Summer General Meeting were briefly reviewed by Professor Kersey. With respect to the industry speaker program, the importance of commenting and replying to the letters of J. L. Callihan, chairman of the subcommittee, were stressed.

District Student Prizes for Papers

Various views were expressed in regard to this subject to the effect that the first prize of $25 and a certificate, and the second prize consisting of a certificate only, were inadequate, and more interest could be aroused in the District Student Prize Paper Competition if additional prizes could be provided. One counselor expressed the view that the trip to the Summer General Meeting for the winner of the first prize was not of sufficient value and that it would be better to give the money to the vice-presidents to use. Professor R. C. Lewis, chairman of District 8's Committee on Student Activities expressed the view that while the $25 District Prize did not mean much, the trip to the Summer General Meeting was well received and he would like to see it continued. Professor G. D. Sheckels of Montana State College explained that it was difficult to get the students to compete at the Branch level but it was less difficult later to get them to compete at the District level and several other speakers thought the Student Branch prizes at the Branch level should be increased. Chairman Morton explained that the Student Prize Paper Competitions were under study and he appreciated the value of the excellent student presentations. These greatly enabled students later in the presentation of their ideas and reports to industry.

National, District Student Membership

Professor Kersey called attention to a letter received from the past chairman of the Student Branches Committee R. F. Danner which indicated that, as of February 1 of this year, there was an increase in student enrollment of approximately 18 per cent as compared with the previous year, whereas in Districts 8 and 9 the increase was approximately only 12.8 per cent and 14.7 per cent, respectively. As the gains were not quite as high as at the national level the question was raised as to whether the counselors in these Districts had been sufficiently active.

As to ways in which new chairmen might interest students in the Branches, the following examples were cited. At the University of British Columbia one hour a week just after lunch is devoted to meetings. At the first meeting the counselors of the AIEE and the Institute of Radio Engineers outline each organization's aims. Other counselors reported that *Electrical Engineering* was very readable and the bimonthlies were valuable. In one school copies were made available on a table in the laboratory. These showed evidence of a great deal of use.

Contests in using the slide rule and taking a motor apart and putting it together, were found valuable. Professor Lewis reported that in the Los Angeles Section the idea had been dispelled that we were only interested in power but are also interested in electronics. He drew attention to the good job which the Sections have been doing in furthering interests of students in the AIEE. He expressed the wish that the officers would watch the Young Engineers Council in the Los Angeles Section, notice the membership increase, and follow the pattern in the other Sections.

SPEAKERS AT THE GENERAL SESSION (left to right) W. H. Mott, general chairman; N. S. Hibshman, AIEE secretary; W. W. German, Montana Power Company; T. Sullivan, Mayor of Butte; J. R. Walker, AIEE vice-chairman; M. D. Hooven, AIEE president; Arthur Linforth, Anaconda; and R. C. Setterstrom, vice-chairman.

PRESIDENT HOOVEN being inducted into the Salish-Kooteray tribe. He was given the name of "Suwechem," meaning "lightning."

At the conclusion of the meeting a student paper on "Electroluminescence" by Frank A. Ruegg was presented by George Dotto, incoming Student Branch Chairman at the University of British Columbia. The paper had been awarded second prize in the District 9 Student Prize Paper Competition. The three methods of converting electrical energy into light were reviewed together with the possibilities of obtaining any color from three phosphors, their limitations and efficiencies. Considerable improvement has been made in electroluminescence during the past three years and the phenomenon was demonstrated.

Technical Sessions

Many of the papers in the ten technical sessions were particularly applicable to the problems of the region, such as those which dealt with the applications to mining work, electric mine haulage equipment, safety features in connection with electric and diesel-electric locomotives, as well as cathodic protection. Three of the papers pertained to the aircraft industry and had to do with explosion-proofing instrumentation equipment for flight-test use, an exciter-voltage regulator for environmental-free aircraft alternators, and a spot size measuring instrument. In the field of television some of the papers were particularly applicable to mountainous regions and dealt with propagation, community antennas, and satellite booster-station allocation developments.

Magnetic Amplifiers

In the session on magnetic amplifiers five papers were presented with Harry Eckerle presiding. The first paper described mag-amp regulating systems for synchronous machines. This was presented by J. V. Kresser. In the second paper, magnetic amplifier sequential circuits of the asymetrical type were presented by A. S. Fitzgerald, a pioneer in magnetic amplifiers. The response of the magnetic amplifier flip-flop circuits was made to act like the electron-tube flip-flop circuits. Another paper about a signal discriminating magnetic amplifier was presented by G. E. Lynn which would respond to a-c or d-c signals and a combination of both, with a two per cent linearity characteristic and selectivity within one per cent of full-scale value. In the last paper, which was presented by R. V. Evans, the design of an exciter-voltage regulator for environmental-free aircraft alternators was described. This small exciter-voltage regulator was designed to withstand 10-G vibration tests and the regulation of the generator from no load to full load was less than $1\frac{1}{2}$ volts.

THE VIGILANTES Committee (left to right) Cecil Kirk, chairman, Verne Mac Donald, John Cromer, George Scotten.

Transmission and Distribution

In this session four papers were presented with E. C. Starr presiding. The first paper by T. M. Austin of the Bureau of Reclamation was presented by Holland Farr, and the design and construction of the Bureau of Reclamation 230-kv lines in North Dakota were described. Questions raised in connection with the discussion concerned the cost of line per mile, the transposition, and the reinforcing of tower footings, due to soil conditions and electrolytic action. The towers were set in concrete footings with a tower footing resistance of 15 ohms and only one ground rod per footing.

The second paper was presented by M. W. Anderson and dealt with the preliminary investigation of field testing and analysis of results incident to interruption of both exciting and parallel load currents to a bank of power autotransformers by an air-break disconnect switch. No hazard to equipment or personnel resulted from the interruption of autotransformer exciting currents by an air-break disconnect switch under a stable voltage source. Easy interruption was possible because the tertiary winding of the bank was delta connected and the neutral grounding was of low impedance.

The third paper was presented by T. A. Combellick and dealt with the advantages and reliability of microwave for communication and relaying on power systems.

The last paper was presented by B. J. Wilson of the Naval Research Laboratory and explored the limitations of how finely one might control the voltage deviations on systems up to 250-kva.

Cathodic Protection

In a well-rounded symposium on this subject, with Professor R. M. Wainwright presiding, the latest practices and experiences were brought out in the protection of electric distribution systems, telephone underground systems, gas distribution systems, buildings, refineries, and industrial plants. The last speaker on the panel, Professor Wainwright, reviewed the various types of measurements necessary in connection with cathodic protection, and he advised that good instruments were essential as these were precision measurements which had to be made with a high degree of accuracy. Multimeters and a group of special types of instruments for corrosion work have been developed.

Community Antennas, Propagation, Satellites

In this session, Dr. G. R. Town presiding, four papers were presented. The Tropospheric Research Program of the National Bureau of Standards was described by J. W. Herbstreit who illustrated with colored movies the erection of a transmitter on top of Cheyenne Mountain. Meteorological conditions associated with the observed results from the Cheyenne Mountain transmitter had been studied. Special meteorological instruments and microwave refractometers developed by the Bureau have been installed on a 500-foot tower along the transmission path near Haswell, Colo.

In another paper, satellite and booster station allocation developments were described by O. W. B. Reed, Jr., and in still

another paper the experience in receiving and rebroadcasting uhf television signals was presented by Verne Russell. The last paper dealt with the problem of community television antenna systems and it was presented by A. S. Taylor. These systems, which usually operate beyond the normally expected horizon, were discussed from the point of view of the history and prospects of the systems, the antenna site, cables, amplifiers, and the distribution systems employed, as well as the nontechnical problems.

Entertainment

Monday evening an informal Western outing was held at Columbia Gardens. An outdoor picnic dinner featuring Butte pasty was served, followed by a Western mixer dance and square dance exhibitions. President Hooven was inducted in the Salish-Kooteray Indian tribe and given the name of "Suwechem" meaning "lightning."

On Tuesday evening a number of members and guests made the 178-mile round trip to Virginia City where much of the atmosphere of the old gold-mining days, including some of the original furnishings and merchandise, still remains. Old-time entertainment was given in the Virginia City playhouse.

On Wednesday evening a dinner dance was held at the Butte Country Club. Following the dinner, General Chairman W. H. Martin introduced the officers of the Institute and guests at the speaker's table as well as the chairmen of the working committees.

Committees

Officers of the Pacific General Meeting Committee were as follows: Vice-President John R. Walker, Chairman W. H. Mott, Vice-Chairman R. C. Setterstrom, Secretary D. E. Kampschror, and Treasurer R. C. Nealey.

The chairmen of the working committees were as follows: Technical Program, E. W. Schilling; Vigilantes, C. H. Kirk; Hotels and Registration, R. J. Labrie; Entertainment, R. J. Carlson; Inspection Trips, N. V. Anderson; Ladies, Mrs. C. A. Champ; Publicity, W. H. Blankmeyer.

Aircraft Electrical Applications Conference Will Be Held in Los Angeles, Oct. 25–27

THE 1955 AIEE Technical Conference on Aircraft Electrical Applications will be held in Los Angeles, Calif., Tuesday, Wednesday, and Thursday, October 25, 26 and 27 with headquarters at the Hollywood Roosevelt Hotel. A 3-day technical program has been arranged covering up-to-the-minute subjects that will be of interest to all those in the aircraft electrical field. Arrangements have also been completed for a social program for the ladies.

Technical Program

Twenty-four technical papers are scheduled for this meeting. Subjects include new designs in components and equipment, engineering department management, laboratories and testing, plus aircraft a-c power systems and controls. Nationally known speakers will discuss latest developments.

Luncheon

A luncheon will be held at the Institute of Aeronautical Sciences Building. Guest speaker will be Brigadier General Leighton I. Davis, commander, Holloman Air Development Center. General Davis is a graduate of West Point and has spent his entire career in the Air Force. During World War II, he was chief of the Armament Laboratories at Wright Field and was instrumental in the development of the Draper-Davis sight. Prior to his present command, he was director of developments at the Air Research and Development Command, Baltimore, Md. Luncheon reservations will be made at the time of registration and transportation will be available from convention headquarters to the Institute of Aeronautical Sciences Building.

Ladies Events

Ladies who attend are promised a varied and exciting schedule of activities.

A sightseeing bus trip to Forest Lawn Memorial Park, Tuesday 8:30 a.m. to 1:00 p.m., including a special showing of the famous stained-glass window copy of Leonardo Da Vinci's "The Last Supper," and mural of "The Crucifixion." From Forest Lawn, the tour will go to Universal Movie Studios and the Hollywood Bowl. From 3:00 to 5:00 p.m., there will be a get-acquainted tea at the Redwood Room of the Hollywood Roosevelt Hotel, no charge. Tuesday evening, ladies may accompany the men on a tour of the Columbia Broadcasting System's (CBS) television studios.

Wednesday will be left free for shopping, and other sightseeing. A bus tour of Beverly Hills and other points of interest, followed by lunch at the Farmers Market, will begin at 10:30 a.m. Thursday. Disneyland and Knotts Berry Farm, both in the Los Angeles area, are scheduled for Friday, 8:30 a.m. Tickets for the bus tours each day will be approximately $4.00.

Field Trips

A tour of the CBS television studio, Tuesday at 6:45 p.m., is one of the many interesting field trips that has been arranged. A trip through this studio, which houses both mechanical and electrical marvels, will be a revelation of the intricacies of producing and broadcasting a televised program.

Air transportation committee meetings will be held on Wednesday evening, and on Thursday evening there will be an Aircraft Electrical Society Display. Special trips to local aircraft manufacturing facilities will be made upon request. Evidence of security clearance will usually be necessary for these trips.

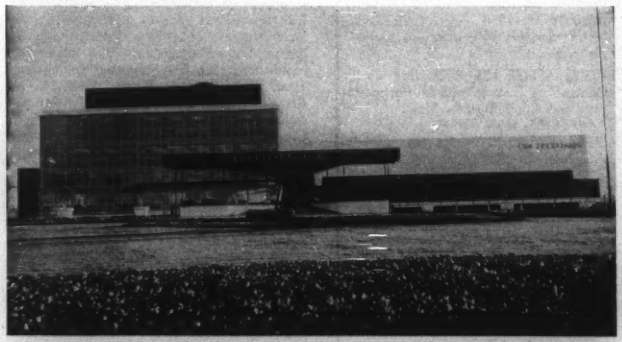
Friday will be highlighted by a trip, starting at 8:30 a.m., to Disneyland including "Fantasyland," "Adventureland," "Frontierland," and a "Rocket Trip to the Moon" in "Tomorrowland." The tour will continue in the afternoon to Knotts Berry Farm and Ghost Town for dinner.

Registration

Registration facilities will be open at the Hollywood Roosevelt Hotel Monday evening—6:00 to 9:00 p.m., on Tuesday, Wednesday and Thursday—8:00 a.m. to 5:00 p.m. Advance registration is encouraged to enable the committee to adequately prepare programs, tickets, etc. There will be no registration fee for AIEE members and the fee for nonmembers will be $1.00. All registration and ticket fees will be collected upon arrival at the registration desks. Advance registration for the conference may be made by writing to H. B. Anderson, Westinghouse Electric Corporation, 600 St. Paul Avenue, Los Angeles 17, Calif.

Hotel Reservations

One hundred rooms have been set aside for members and guests at the Hollywood Roosevelt Hotel where rates start at $9.00 for a single room and $11.00 for a double.



TELEVISION CITY, the Columbia Broadcasting System's television studio in Los Angeles, Calif., is on the list of inspection trips for those attending the Aircraft Electrical Equipment Conference in Los Angeles, Calif., this month, October 25–27.

Future AIEE Meetings

1955 Fall General Meeting
Morrison Hotel, Chicago, Ill.
October 3–7, 1955
(*Final dates for *TP—closed; †CP Syn.—closed; CP Ms—closed*)

Motor Application and Problems in Heating and Cooling Conference
Chase-Park Plaza Hotel, St. Louis, Mo.
October 19–20, 1955
(*Final date for submitting papers—closed*)

Aircraft Electrical Equipment Conference
Hollywood Roosevelt Hotel
Los Angeles, Calif.
October 25–27, 1955
(*Final date for TP—closed, CP—closed*)

Middle Atlantic Textile Conference
North Carolina State College, Raleigh, N. C.
November 3–4, 1955
(*Final date for submitting papers—closed*)

AIEE-IRE-ACM Eastern Computer Conference
Hotel Statler, Boston, Mass.
November 7–9, 1955
(*Final date for submitting papers—closed*)

Electrical Techniques in Medicine and Biology Conference
Shoreham Hotel, Washington, D. C.
November 14–16, 1955
(*Final date for submitting papers—closed*)

EJC-AIEE Nuclear Energy Conference
Cleveland, Ohio
December 12–17, 1955
(*Final date for submitting papers—closed*)

Winter General Meeting
Hotel Statler, New York, N. Y.
January 30–February 3, 1956
(*Final date for TP—closed, CP—Nov. 30*)

South West District Meeting
Dallas, Tex.
April 2–4, 1956
(*Final date for TP—Jan. 3, ‡DP—Feb. 2*)

Great Lakes District Meeting
Fort Wayne, Ind.
April 16–18, 1956
(*Final date for TP—Jan. 16, DP—Feb. 16*)

AIEE, ASME, ISA Recording and Controlling Instruments Conference
Bradford Hotel, Boston, Mass.
April 26–27, 1956
(*Final date for TP—Jan. 26, CP—Feb. 24*)

North Eastern District Meeting
Rochester, N. Y.
May 2–4, 1956
(*Final date for TP—Feb. 1, DP—Mar. 2*)

*TP—Transactions paper
†CP Syn.—Conference Synopsis, CP Ms—Conference Manuscript (The CP Syn. date is 15 days before the CP Ms date)
‡DP—District papers

THE XFY-1 NAVY FIGHTER—the plane that can take off straight up and fly horizontally at more than 500 miles an hour—has made more than 350 vertical flights since it was rolled out of the San Diego, Calif. plant of the Convair Division of General Dynamics Corporation last March. Called "Pogo" by the Convair men who designed and built it, the XFY-1 made its early flights in an ingenious tethering rig built into an airship hangar at Moffett Naval Air Station, Calif.

If rooms are not available when requested, reservations will be made at other nearby hotels. Reservation requests also should be sent to H. B. Anderson. It is requested that reservations be sent as early as possible.

Aircraft Electrical Society Display

Delegates will have an opportunity to attend the Twelfth Annual Aircraft Electrical Society Display, to be held at the Pan-Pacific Auditorium, Thursday evening, October 27, Friday afternoon, and evening, October 28. Set up to promote the interests of the aircraft electrical industry, this show will feature products of more than 100 component manufacturers. It is expected that more than 12,000 engineers, technical personnel, and business executives will attend. Admittance to the show is by invitation only and tickets will be available at the registration desk. There will be no charge for the tickets.

General Committee

Chairman of the Aircraft Electrical Technical Conference is F. L. Lyons. T. B. Holliday is in charge of the technical program, assisted by T. B. Owen. Other committee members are: O. Baumann, Jr., secretary; E. A. Freitas, finance; J. L. Elliott, assisted by G. Mayhew, hotel arrangements; C. R. Moore, program presentation arrangements; H. B. Anderson, registration; D. H. Stephens, field trips; J. J. Pierro, publications; Mrs. H. F. Rempt, ladies activities; H. F. Rempt, assisted by W. C. Bryant, banquet; C. W. Chandler, assisted by C. W. Bozarth and J. Camlin, publicity; R. S. Gardner, Headquarters representative.

The tentative technical program follows:

Tuesday, October 25

9:30 a.m. Morning Session

Chairman: D. H. Scott

55-825 Correlation of the Thermodynamic and Electrical Characteristics of Blast-Cooled Generators. *Daniel Friedman*, Naval Research Laboratory

CP55-826 The Vibration Susceptibility of Certain Existing Airborne Electrical Switch Terminations. *M. F. H. Gouverneur* and *M. B. Levine*, Armour Research Institute

55-827 Sensing Methods Applicable to a 3-Phase Load Transfer Contactor. *R. W. Stineman*, Boeing; *P. L. Epstein*, Hartman Electrical

2:00 p.m. Afternoon Session

Chairman: W. V. Boughton

CP55-828 A Transistorized Overvoltage Relay. *N. F. Schuh*, Westinghouse

CP55-617 Explosion Proofing Instrumentation Equipment for Flight Test Use. *B. F. Hager*, Boeing

CP55-829 A Glow Switch for Aircraft A-C Overvoltage Protection. *O. C. Walley*, Jack and Heintz

CP55-830 An Investigation of Temperature Controllers for Windshield Anti-icing. *C. L. Hennigan*, Northrop

55-831 The Development of a Static Voltage Regulator for Aircraft A-C Generators. *H. H. Britten* and *D. L. Piette*, General Electric Company

Wednesday, October 26

9:00 a.m. Morning Session

Chairman: D. W. Exner

CP.* Organization and Management of the Engineering Department of an Aircraft Equipment Manufacturer. *R. A. Rugge*, Minneapolis-Honeywell

CP55-832 Managing an Airline Engineering Department. *P. A. Wood*, United Air Lines

CP55-833 Organization and Management of the Engineering Department in the Aircraft Industry *E. C. Wells*, Boeing

NEW PREPRINT PRICES

40¢ to Members
80¢ to Nonmembers

MINIMUM ORDER by mail $1.20 unless accompanied by remittance or coupons. All nonmember orders *must* be accompanied by remittance.

COUPON BOOKS in ten-dollar denominations may be purchased.

NUMBERED PAPERS only are available.

SEND ORDER and remittance to:

AIEE Order Department
33 West 39th Street,
New York 18, N. Y.

12:00 p.m. Luncheon

2:30 p.m. Afternoon Session

Chairman: G. A. Phillips

CP55-834 A Laboratory for the Evaluation of A-C Electric Systems in Aircraft. *B. H. Owens*, Douglas

CP55-835 An Airline-Operated Engineering Test Center. *E. A. Jensen*, United Air Lines

CP55-836 Simplified Test Method for the D-Axis Transient Reactance and Time Constant. *C. F. Yoh*s, Westinghouse

7:00 p.m. Subcommittee Meetings

Thursday, October 27

9:00 a.m. Morning Session

Chairman: E. F. Kotnik

55-837 Maximum Overvoltage on Aircraft A-C Generators After Sudden Removal of Load. *R. E. Klokow*, Westinghouse Electric Company

CP55-838 Co-ordinated Protection of a Multi-generator A-C Aircraft Electrical System. *R. P. Sedgwick*, Douglas

CP55-839 New Requirements of A-C Ground Power Supplies. *V. M. Urban*, Northrop

55-840 Precision Low Frequency Inverter for Aircraft. *M. E. Douglass* and *J. R. Lavender*, General Electric Company

2:00 p.m. Afternoon Session

Chairman: John Maxian, Jr.

CP55-841 The Control of Aircraft A-C Generating Systems Is Simple. *R. E. Bagnoli*, Douglas

55-842 The Effect of Machine Impedances on the Unbalance 3-Phase Voltage Synchronous Generators. *T. F. Hardman*, Westinghouse

55-843 An Oil-Cooled A-C Generator for High-Speed, High-Altitude Aircraft. *W. J. Shilling* and *H. J. Braun*, Westinghouse

CP55-844 A High Performance Control for a Constant Speed Drive System. *E. W. Erikson*, Sundstrand

55-845 Air Turbine Drives—Performance and Limitations. *L. Royce* (Re-presented for discussion)

5:15 p.m. Evening Session

Air Transportation Committee Meeting, Aircraft Electrical Society Display at Pan-Pacific Auditorium

AIEE Board of Directors Report for First Meeting of Administrative Year

THE FIRST MEETING of the Board of Directors for the administrative year 1955–1956 was held in conjunction with the Pacific General Meeting in Butte, Mont., on Wednesday, August 17, 1955. Present were: President M. D. Hooven, Past Presidents E. B. Robertson and A. C. Monteith; Directors D. I. Cone, L. F. Hickernell, R. E. Kistler, E. S. Lammers, T. M. Linville, A. C. Muir, C. S. Purnell, J. D. Tebo, P. G. Wallace, J. C. Woods; Vice-Presidents Bradley Cozzens, E. R. Jones, W. J. Miller, C. T. Pearce, S. M. Sharp, C. M. Summers, J. C. Strasbourger, J. R. Walker; Treasurer W. J. Barrett; Secretary N. S. Hibshman. By invitation: W. B. Morton, Chairman of the Committee on Student Branches and AIEE member of the Executive Committee of Engineers Joint Council; J. J. Anderson, Assistant to the Secretary; W. D. Rugg, Opinion Research Corporation.

Resolutions

Resolutions were voted as follows: (1) Extending thanks and compliments to the Anaconda Copper Company, the Montana Power Company, Districts 8 and 9, and the Montana Section of AIEE for hospitality and many courtesies to the Board and all members and guests of AIEE attending the 1955 Pacific General Meeting. (2) Greetings to Sir Arthur P. M. Fleming, Local Honorary Secretary for Great Britain, who is recovering from a serious illness. (3) Congratulations and offers of support to Past President Donald A. Quarles, recently appointed Secretary of the U. S. Air Force.

Membership

The Board approved applications for admission and transfer adding to the rolls of the Institute the following: 8 Fellows, 73 Members, 299 Associate Members, 40 Affiliates, and 37 Student members.

The election of James F. Fairman to be an Honorary Member of AIEE was confirmed by the Secretary's announcement of a unanimous vote of the Board. The presentation will be at the 1956 Winter General Meeting in New York, N. Y.

C. S. Ghosh, professor of electrical engineering at the Indian Institute of Science, Bangalore, India, was elected Local Honorary Secretary for Southern India to replace Professor M. S. Thacker who resigned because of his appointment to be director of the Council of Scientific and Industrial Research of India.

Finances

The Treasurer reported a balance in the General Funds of the Institute of $364,050.01 on July 31, 1955 as compared with $226,819.30 at the same date a year ago. The Finance Committee reported dues collections May 1 to July 31, 1955 as $501,500.00 as compared with $399,100.00 for the same period last year.

The Board approved sending election ballots to overseas members as first-class mail to insure return in time for counting.

On recommendation of the Finance and Planning and Co-ordination Committees, the Board voted that, effective with the Winter General Meeting of 1956 the registration fees shall be as follows:

	Members	Non-members
For General Meetings	$5.00	$8.00
For District Meetings	$3.00	$5.00

Exemptions and other policies relative to meeting registration fees remain unchanged.

Constitution and Bylaws

The Board of Directors approved amendments to the Bylaws to the following effects: (1) To permit the Board of Examiners to accept as partial credit towards membership requirements graduation from certain other curricula than those accredited by Engineers Council for Professional Development; (2) To recognize an advanced or graduate degree in engineering or science from an approved engineering college as equivalent to the bachelors degree from an accredited curriculum in satisfying admission requirements; (3) To recognize the professional engineering license as qualifying a maximum of four years of the experience on which it is predicated for credit toward constitutional requirements for membership in AIEE; (4) To clarify the position of the Student member "transferring" to Associate Member with respect to Constitutional requirements for membership; (5) To create three new technical committees: Communication Theory, Dielectrics, and Solid State Devices; (6) To authorize Student members to subscribe to one edition of the "Bimonthlies" at a special price of $1.00/year; (7) To stop the theoretical reduction of Section appropriations by the amount of unexpended previous appropriations and to eliminate financial reports from Sections. (The Constitution and Bylaws as amended to August 26, 1955 will be published in pamphlet form before October 1, 1955. No action should be taken on the basis of the foregoing unofficial summary.)

Opinion Poll

Dr. W. D. Rugg of Opinion Research Corporation presented a report on the AIEE 1955 Member Opinion Poll, conducted by personal interviews among a scientifically selected sample of AIEE members. The results of the poll are being distributed to officers and committees for study. A report on the conduct and results of the poll will appear in a future *Electrical Engineering*.

A New Medal

The Members-for-Life Fund Committee proposed and the Board approved the establishment of a new series of awards to be supported by the Members-for-Life Fund. A medal with a certificate is to be presented to an Institute member for outstanding achievement "in some particular field of Electrical Engineering or Electrical-Engineering education." The first medal is to be presented in the field of education at the Fall General Meeting in Chicago, October 1956. (See page 937 of this issue of *Electrical Engineering* for a complete report.)

Unity

W. B. Morton, AIEE representative on the Executive Committee of Engineers Joint Council, announced that he has prepared a paper (appearing in this issue of *Electrical Engineering*, pages 885–91), "The Struggle for Unity." He said he hoped the Sections would comment on the organization plan offered.

Student Branch Finances

Mr. Morton, as chairman of the Committee on Student Branches, obtained the approval of the Board of Directors for the payment of the total $1.00-per-member Branch allotment as soon as possible after November 15, and for the abolition of financial reports from the Student Branches.

New Building

Past President Elgin B. Robertson represented AIEE on a special negotiating com-

Incoming and Outgoing Board of Managers, Lehigh Valley Section

INCOMING members of Lehigh Valley Section's Board of Managers (1955–56) got together at a dinner meeting, June 24. They are (left to right): J. C. Gray, R. H. Demmy, D. D. Smith, H. D. Moore, B. B. Kern, H. R. Steward, D. L. Greene, C. J. Mayer, W. F. Dunkle, M. F. Rosol, S. C. Townsend, J. W. Gehrke, G. A. Irland, C. L. Eichenberg, L. L. Nonemaker, P. H. Robbins, E. L. Stagliano, E. P. Winklespecht, W. F. Mackenzie, G. E. May, and R. J. Holland. Absent were: F. S. Fehr, L. V. Bewley, R. E. Peterson, W. M. Creitz, F. R. Wille, E. F. Weaver, T. A. Schlegel, D. J. Glick, D. E. Albertson, and L. F. Anderson.

OUTGOING members of the Section's Board of Managers (1954–55) were also at the meeting. They are (left to right): J. H. Black, R. H. Demmy, S. J. Litrides, H. D. Moore, B. B. Vern, H. R. Steward, W. F. Dunkle, S. C. Townsend, G. A. Irland, M. F. Rosol, D. L. Greene, J. W. Gehrke, F. M. Fuller, C. L. Eichenberg, J. B. Homsher, P. H. Robbins, E. L. Stagliano, W. F. Mackenzie, V. F. Stuebner, G. E. May, and C. J. Mayer. Absent were: R. D. Evans, F. S. Fehr, H. J. West, R. E. Peterson, W. T. Joseph, D. K. Shoemaker, D. E. Albertson, L. F. Geiger, E. F. Weaver, N. N. Smeloff, and M. H. Gring.

mittee with representatives of the other four societies interested in a new engineering societies building. This committee was needed because the "Five Societies" had failed to take concerted action on the report of "The Five Presidents." It now appears likely that the "Five Societies," AIEE, American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Institute of Chemical Engineers, and The American Society of Mechanical Engineers, will form a new, 15-man committee with a $75,000 budget to study and recommend the best location for a new building.

Future Meetings

The Board of Directors will meet in Chicago, Ill., on October 6, 1955; in New York, N. Y., on February 2, 1956; in Dallas, Tex., on April 4, 1956; and in San Francisco, Calif., on June 28, 1956.

Insulation Classification Changes Suggested by Co-ordinating Committee

AIEE STANDARD NO. 1 on "General Principles Upon Which Temperature Limits Are Based in the Rating of Electric Machines and Other Equipment" is a guide for the selection of suitable operating temperatures for electric apparatus, depending on the thermal endurance of the insulating materials employed. For this purpose, insulating materials are grouped in accordance with their chemical composition into classes O, A, B, H, and C. It has been found, however, that the present definitions are inadequate for proper classification of new synthetic insulating materials, since extensive tests have shown that some of these materials have greater temperature endurance than the existing definitions imply.

Thus, several Institute committees are developing test procedures for the temperature evaluation of new insulating materials and insulation systems in order to determine how these new products can be used properly in electric apparatus. At the June 1955 meeting of the Institute in Swampscott, Mass., 12 papers were presented in this field; and 6 different test procedures (codes) already have been put into final, or nearly final, form.

As a result, the newly reorganized AIEE Standards Coordinating Committee No. 4 met on June 28, 1955 to consider how to make the revision of AIEE Standard No. 1 that is evidently needed. It was decided the changes should be made in two steps, one immediate and one long range. First, an addendum to AIEE 1, constituting an interim revision, will be submitted to the AIEE Standards Committee for approval and publication in the immediate future.

Second, a general revision of AIEE 1 will be undertaken and completed as soon as possible, but not until the new provisions have been discussed thoroughly and agreed upon.

The Immediate Program

The immediate need is to provide for the proper classification and use of those newly developed synthetic wire enamels which have been shown to withstand Class B or even higher temperatures. These enamels are largely organic in chemical structure and, hence, are presently confined to Class A temperature limits. For this reason, the committee at the June 28 meeting decided upon the wording of the following proposed addendum to AIEE Standard No. 1.

Proposed Addendum to Standard

The February 1954 Revision of AIEE Standard No. 1 authorized the evaluation of new insulating materials and systems by accelerated life tests (paragraphs 1–3, 1–4) with the objective of shortening the experience required. Recent developments have made available new synthetic insulating materials that have been and are being so evaluated, some of which promise to have extensive use in electric equipment.

To provide recognition of those new synthetic materials that are suitable for operation at Class B or Class H temperatures, the definitions of Classes B and H insulations as they appear in Table I of AIEE Standard No. 1, February 1954, are revised to the following. Class B insulation consists of materials or combinations of materials such as mica glass fiber, asbestos, etc., with suitable bonding substances. Other materials or combinations of materials, not necessarily inorganic, may be included in this class, if by experience or accepted test* they can be shown to be capable of operation at Class B temperatures. Class H insulation consists of materials or combinations of materials such as silicone elastomer, mica, glass fiber, asbestos, etc., with suitable bonding substances such as appropriate silicone resins. Other materials or combinations of materials may be included in this class if by experience or accepted tests* they can be shown to be capable of operation at Class H temperatures.

This is an interim change, pending a complete revision of AIEE Standard No. 1. It is important to recognize that other characteristics, in addition to thermal endurance, such as mechanical strength, moisture resistance, corona endurance, etc., are required in varying degree in different applications for the successful use of insulating materials.

Test procedures published or under preparation include the following: Test Procedure for Evaluation of Systems of Insulating Materials for Random-Wound Electric Machinery AIEE Standard No. 1C, January 1954; Test Procedure for Evaluation of Flexible Sheet Materials (under preparation); Test Procedure for Evaluation of Magnet Wire (under preparation); Test Procedure for Evaluation of Systems of Insulating Materials for Dry-Type Power and Distribution Transformers (under preparation); Test Procedure for Evaluation of Systems of Insulating Materials for Form-Wound Electric Machinery (under preparation); and Test Procedure for Evaluation of Systems of Insulating Materials for Specialty Transformers (under preparation).

*Test procedures for the evaluation of insulating materials and insulation systems are under development by the Institute. It is recommended that whenever feasible the evaluation methods in such test procedures should be followed.

The Long-Range Program

It is intended that some new concepts will be added in the revision, carrying forward the ideas already given in paragraph 1–4 of the present standard. These will include general principles for the temperature classification of the various kinds of insulating materials, and a guide for the development of test procedures to provide a basis for this classification. General principles will also be included for the temperature classification of complete insulation systems, and for the development of suitable system test procedures, that are or will be established by the technical committees of the Institute who are concerned with the different types of apparatus. A principal problem will be to consider means for specifying temperature ratings of equipment that will be compatible with the temperature characteristics of insulating materials.

Working groups will be appointed to carry out the several parts of this program, and their proposals will be submitted to the entire committee for revision.

This progress report of Co-ordinating Committee No. 4 of the AIEE Standards Committee was prepared by the working group composed of P. L. Alger, E. B. Paxton, H. G. Zambell, and W. W. Satterlee.

New Air Secretary Quarles Is Past President of AIEE

THE NEW SECRETARY of the Air Force, Donald A. Quarles, is a recent Past President (1952–53) of the AIEE and has been an active member in the Institute for many years. He became an Associate Member in 1923 and was transferred to the grade of Fellow in April 1941. He received an honorary doctor of engineering degree from New York University's College of Engineering. He has served on the following Institute committees: Finance (1944–48, Chairman 1946–48); Edison Medal (1945–47, 1953–55); Electronics (1945–47); Instruments and Measurements (1945–46); Library Board, United Engineering Trustees, Inc. (1945–46); Board of Trustees, AIEE Retirement System (1945–48); Planning and Co-ordination (1946–48); Headquarters (1946–48); Lamme Medal (1947–50); Management (1948–52); Board of Directors (1944–48; 1952–55); Board of Trustees, United Engineering Trustees, Inc. (1948–54); Executive (1952–54, Chairman 1952–53); John Fritz Medal (1953–55). He is author of a number of articles appearing in *Electrical Engineering*, the most recent "Engineers and Our National Well Being." (See April 1955 issue, pp. 295–7.) Secretary Quarles entered Government service in 1953 as Assistant Secretary of Defense, a specialist in guided missiles. He was president of the Sandia Corporation,

NEW SECRETARY OF THE AIR FORCE Donald A. Quarles (right) is congratulated by Secretary of the Army, Wilber M. Brucker (left). Secretary of the Navy Charles S. Thomas and Secretary of Defense Charles E. Wilson (center, left and right) are also present to offer congratulations.

N. Mex., subsidiary of Western Electric for the Atomic Energy Commission. Most of his career has been with Western Electric and the Bell Telephone Laboratories. (See August *Electrical Engineering*, page 706). Mr. Quarles was born in Van Buren, Ark., and attended high school there. Later he taught in Van Buren High School. He is a graduate of Yale (1916) where he obtained a degree in mathematics. After graduation he enlisted in the U. S. Army and went to Officers Candidate School. Later he was sent to France where he became an artillery captain in the "Rainbow Division." He also served in Germany. Mr. Quarles was mayor of Englewood, N. J., from 1946–48 and previously had been a councilman there. He was chairman of the Bergen County, N. J., Sewer Authority (1945–50) and director of Englewood's Citizens National Bank.

Application of Motors to Space Heating, Cooling Equipment Meeting Set for Oct. 19–20

THE APPLICATION of Motors to Space Heating and Cooling Equipment Conference will be held in St. Louis, Mo., October 19–20. The Chase Hotel will be conference headquarters. Sponsors are the Single Phase and Fractional Horsepower Subcommittee of the Committee on Rotating Machinery and the St. Louis Section of AIEE.

Technical Sessions

The technical program consists of 16 papers offering broad coverage of the conference subject. Sessions will be held in the Regency Room of the Chase Hotel.

Special Activities

Luncheons have been planned for both Wednesday and Thursday. A joint banquet meeting with the St. Louis Section will be held Wednesday evening on the Starlight Roof of the hotel. Mr. Charles G. Arps, Allis-Chalmers Manufacturing Company, will give an address at this meeting, "The Personal Equation."

Hotel Reservations

For hotel reservations, preregistration forms, and programs write to: John K. Howell, Westinghouse Electric Corporation, 411 North 7th Street, St. Louis, Mo. The registration fee is $5.00. Checks should be made payable to C. B. Fall, finance chairman.

Committee

Robert F. Munier, chief motor engineer, The Emerson Electric Manufacturing Company, is general chairman. Other committee chairmen, are: C. D. Fall, finance; J. L. Hamilton, program; W. E. Korsan, arrangements; John K. Howell, registration and reservations; and Jack Roomy, publicity.

The tentative technical program follows:

Wednesday, October, 19

8:30. a.m. Registration

10:00 a.m. General Session

10:30 a.m. Session I

Presiding: R. F. Munier, The Emerson Electric Manufacturing Company

Starting Equipment for Air Conditioning and Refrigeration Machines. *J. J. Mellon*, Allen-Bradley Company

Controls for Hermetic Motors. *R. E. Mehrey*, Square D Company

12:15 p.m. Luncheon

We Are in the Status Quo. *A. Carl Weber*, Laclede Steel Company

2:00 p.m. Session II

Presiding: J. H. Karr, Robbins and Myers, Inc.

Underwriters' Laboratories Facilities for Testing Air Conditioners and Refrigeration Equipment. *W. A. Farquhar*, Underwriters' Laboratories, Inc.

Design Considerations for Single-Phase Air Conditioning Motors. *M. E. Evans*, General Electric Company

Some Aspects of Application of Permanent Split-Phase Capacitor Motors to Direct-Connected Fans. *R. F. Fricke*, Westinghouse Electric Corporation

Some Aspects of Surge Comparison Testing of Fractional Horsepower Motors. *R. A. Strain*, The Emerson Electric Manufacturing Company

The Use of Permanent Split Capacitor Motors on Small Fan Applications. *G. W. Horner* and *L. D. Jones*, Century Electric Company

Thursday, October, 20

9:00 a.m. Session III

Presiding: W. L. Knaus, General Electric Company

Utility Company Problems Arising from Extensive Air Conditioning Loads. *R. F. Scott*, Southwestern Gas and Electric Company

What Is an Air Conditioning Horsepower? *Paul W. Wyckoff*, Chrysler Corporation

The Heat Pump. *G. S. Whitlow*, Union Electric Company of Missouri, *A. J. Maixner*, Union Electric Company of Missouri

Electric Motors for Cooling Towers Selection, Installation and Maintenance. *H. E. Degler, Philip Oldberg, Jr.*, The Marley Company

12:15 p.m. Luncheon

Persistance, As Applied to Engineers and Engineering. *O. L. Luft*, Union Electric Company of Missouri

2:00 p.m. Session IV

Presiding: J. L. Hamilton, Retired, Century Electric Company

Importance of Location of Inherent Protectors on Hermetic Compressors. *T. O. Pihl*, Tecumseh Products Company, *A. P. White*, Metals and Controls Corporation

Larger Single-Phase Motors. *F. A. List*, Westinghouse Electric Corporation

A New Method for Part Winding Starting of Polyphase Motors. *P. L. Alger, Miss L. M. Agacinsky*, General Electric Company

Alignment Chart to Simplify Fan Motor Selection. *C. G. Veinott*, Reliance Electric and Engineering Company

The Torque Motor—A Special Motor with a Special Purpose. *R. P. Ballou*, Howell Electric Motors Company

HEADQUARTERS for the Conference on the Application of Motors to Space Heating and Cooling Equipment will be the Chase-Park Plaza Hotel in St. Louis, Mo. The conference will take place this month, October 19–20.

Engineering Foundation Makes 26 Research Grants

Grants for engineering research totaling $61,850 for 1955–56 have been made available by Engineering Foundation. These grants will further 26 projects being carried out in university laboratories throughout the United States under sponsorship of the major engineering societies. In a number of cases the grant is contingent upon the project's being able to raise outside support.

Three projects sponsored by the AIEE were approved: $2,000 for wood-pole research with no contingency; $1,850 for study of high-voltage high-frequency dielectric phenomena, also without contingency; and $3,000 for a project on thermal resistivity characteristics of soils, contingent upon the project's receiving $12,000 outside support.

Five grants have been made to projects under sponsorship of the American Society of Civil Engineers. Also, eight projects under sponsorship of the American Institute of Mining and Metallurgical Engineers were allotted grants, and five projects under the auspices of the ASME.

Grants for two joint projects were also approved—$5,000 for Engineers' Council for Professional Development and $1,000 for the Welding Research Council, both without contingency.

The Foundation has also given grants with no contingency involved to three independent projects—$3,000 for prevention of corrosion of water pipes; $500 for the Building Research Advisory Board; and $1,000 for the Council on Wave Research.

Eastern Joint Computer Conference Scheduled for Boston, Mass., Next Month

THEME of this year's Eastern Joint Computer Conference is "Computers in Business and Industrial Systems." The conference will be held in Boston, Mass., November 7–9 at the Hotel Statler. There will be exhibits of manufacturer's equipment and field trips to nearby installations to see demonstrations.

Papers scheduled for the first day of the meeting will concern the role of computers in business. Tuesday's papers will concern cards, tapes and other records in electronic accounting systems and trends in system design. On Wednesday the papers will concern communication and compatibility among electronic computers in business and industrial use.

There will be a cocktail party and reception Monday evening and a luncheon meeting on Wednesday. Chairman at the luncheon meeting will be H. H. Felker, radio development engineer, Bell Telephone Laboratories. W. R. G. Baker, vice-president, General Electric Company, speaker at the luncheon, will present his paper, "Implementing an Industry-Wide Standardization Program."

Tentative Technical Program Eastern Joint Computer Conference

Monday, November 7

Morning General Session

Presiding: Irven Travis, Burroughs Corporation

Keynote Speaker: J. G. Brainerd, University of Pennsylvania

Address by John S. Coleman, Burroughs Corporation

Afternoon Session

Presiding: H. T. Larsen, Ramo-Wooldrige Corporation

Computers in Basic Business Applications. *F. J. Porter*, Consolidated Edison Company of New York

Operations Control with an Electronic Computer. *B. F. Butler*, General Electric Company

Tuesday, November 8

Morning Session

Presiding: E. L. Harder, Westinghouse Electric Corporation

Manual Use of Automatic Records. *Anthony Oettinger*, Harvard University Computation Laboratory

Evaluation of Sorting Methods. *J. C. Hosken*, A. D. Little, Inc.

Document Processing. *R. H. Gregory*, Massachusetts Institute of Technology

Afternoon Session

Presiding: Alston Householder, Oak Ridge National Laboratory

The Computer and Its Peripheral Equipment. *N. Rochester*, International Business Machines Corporation

Computers with Remote Data Input. *E. L. Fitzgerald*, E. I. du Pont de Nemours Company (Inc.)

Developments in Programing Research. *C. W. Adams*, Westinghouse Electric Corporation and Massachusetts Institute of Technology

Storage and Retrieval of Information. *L. N. Ridenour*, Lockheed Aircraft Corporation

Wednesday, November 9

Morning Session

The Role of Communications Networks in Digital Data Systems. *R. C. Mallack*, Bell Telephone Laboratories

Standardization of Computer Intercommunication. *H. R. J. Grosch*, General Electric Company

Discussion: Statements from Manufacturers on Standardization of Magnetic Tape Records

Luncheon Meeting

Presiding: J. H. Felker, Bell Telephone Laboratories

Implementing an Industry-wide Standardization Program. *W. R. G. Baker*, General Electric Company

Conference Summary

Jay Forrester, Massachusetts Institute of Technology

Hoover Medal Fund Receives Anonymous Gift of $5,000

The Hoover Medal Fund has received an anonymous gift of $5,000.00. This announcement was made by Scott Turner, chairman of the Hoover Medal Board of Award, and Dr. David W. R. Morgan, president of The American Society of Mechanical Engineers (ASME).

The medal was established in 1929 through a trust fund established by the gift of Conrad N. Lauer, past president of ASME, to commemorate the principles and ideas of civic obligations and public service exemplified by the life and work of Herbert Hoover. The medal, "awarded by engineers to fellow engineers for distinguished public service," is administered by the Hoover Medal Board of Award consisting of representatives from AIEE, ASME, the American Society of Civil Engineers, and the American Institute of Mining and Metallurgical Engineers.

The first award of the medal was made to Mr. Hoover in 1930. Since then, engineers, leaders of industry, administration, research, and education who have performed some outstanding service to their community, their nation, and their fellow men, have been selected as recipients.

New AIEE Medal Announced; Request Made for Nominees

A new medal has been established in the Institute for an outstanding achievement in some particular field of electrical engineering or electrical-engineering education. The AIEE Members-for-Life Fund Committee has recommended and the Board of Directors has approved this medal, accompanied by a certificate, to be awarded at next year's Fall General Meeting.

In accordance with the "Bylaws of the Medals Provided from the Members-for-Life Fund," the award will be based upon teaching excellence, ability to inspire students to higher achievements, contributions to the teaching of electrical engineering in textbooks and in writings on engineering education, active participation in the work of the professional and educational societies, and contributions to teaching and the profession through research, engineering achievements, and technical papers.

The Members-for-Life Fund is derived from the dues which Members-for-Life continue to pay voluntarily after becoming exempt from further payment in accordance with Institute Bylaws. By a vote of the Board of Directors, the fund was set aside separately to be used for "special purposes rather than for the general purposes of the Institute." In order to administer the accumulated payments, a Members-for-Life Fund Committee was established. Each year it makes recommendations to the Board of Directors for its approval on the use of this money.

So far, the fund has been used solely for defraying expenses to the Summer General Meeting of several district winners of student paper competitions. However, the fund has gradually increased so that it has become possible to sponsor an additional useful project. In considering several proposals, the committee's attention was called to the fact that the Institute is noticeably lacking in medals and awards by which outstanding achievements of members could be recognized—particularly in special fields. Moreover, the Board already has endorsed in principle a recommendation that the available funds can be used for prizes. Therefore, it seemed to the committee that further use of the fund to establish one or more medals was not only a worthy project, but also one meeting approval of contributors.

In considering the several fields in which the award might be made, it was thought that the first medal should be awarded in the field of electrical-engineering education. This is an important field and one in which the Institute has no specific means of recognizing any outstanding achievements.

The presentation of the first medal is to be made at the Fall General Meeting to be held October 1956, in Chicago. The committee invites members to submit names of nominees. Such nominations may be made by procuring a nomination form from AIEE's National Secretary, N. S. Hibshman, 33 West 39th Street, New York 18, N. Y. The form should be accompanied by at least two supporting letters from others who are familiar with the accomplishments and the qualifications of the nominee. It is desirable that at least one letter come from a former student of the nominee. The forms and letters are due at Headquarters not later than May 1, 1956.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Industry Division

Committee on Chemical Industry (*F. S. Glaza, Chairman; R. M. Wainwright, Vice-Chairman; C. R. Olson, Secretary*). Plans of this committee indicate that the coming Winter General Meeting will see a heavy schedule of technical sessions sponsored by this group. Tentatively there are five technical sessions listed, sponsored by the following Subcommittees: Electrochemical Processes, Cathodic Protection, Electrothermal Processes, and Chemical Processes. A special Committee is now being formed in the Southwest to arrange two technical sessions for the Southwest District Meeting which will be held in Dallas, Tex., April 2–4, 1956. Walter E. Silvus is chairman of this group. He will be assisted by representatives from some of the many chemical industries in the Southwest. Assistance will also come from the Houston and North Texas Sections. Many electrical problems peculiar to the chemical industry in this area will furnish subjects for papers and discussions.

Power Division

Committee on Rotating Machinery (*M. L. Schmidt, Chairman; L. O. Dorfman, Vice-Chairman; F. T. Carlson, Secretary*). A brief outline of the activities of the Committee on Rotating Machinery and its various subcommittees, is as follows:

1. Revision of Test Code No. 503 for Synchronous Machines may reach the first draft stage after the Fall meeting.

2. The "Proposed Guide for Operation and Maintenance of Turbine Generators" has been issued as a first draft for approvals.

3. A recommendation of AIEE Coordinating Committee No. 4 for changes to classification of Class A and Class B materials has been reviewed and approved.

4. The Test Code Co-ordinating Subcommittee has completed the final draft of a revision of "Test Code for D-C Machines," AIEE No. 501, and will now ask approval.

5. The material for a first draft of "A Proposed Guide for Determining the Short-Circuit Characteristics of D-C Machines" has been assembled.

6. The Single-Phase and Fractional Horsepower Motor Subcommittee plans to submit a revision of the "Single-Phase Motor Test Code" soon.

7. The Subcommittee on Insulation has completed a "Proposed Test Procedure for Evaluation of Systems of Insulating Materials for Electric Machinery Employing Form Wound Pre-Insulated Coils," applying to machines rated 50–2,000 hp and below 6,600 volts. The "Test Procedure for Evaluation of Systems of Insulating Materials for Random Wound Electric Machinery," formerly AIEE No. 1C, has been revised and a new section has been added giving procedures for analysis and reporting data. A "Test Procedure for Evaluation of Systems of Insulating Materials for Small D-C Field Coils" has been completed, and recommended for trial use. Progress is reported on a "Proposed Test Procedure for a High Voltage Direct Current Dielectric Acceptance Test for New Rotating Machinery Rated 6,000 Volts and Above," and on a final revision to AIEE No. 56, "Proposed Guide for Insulation Maintenance for Large Alternating Rotating Machinery."

Committee on Switchgear (*J. D. Wood, Chairman; J. C. Woods, Vice-Chairman; K. J. C. Falck, Secretary*). A problem encountered in connection with the new proposed method for rating power circuit breakers is to determine the system decrement for both a-c and d-c components of a short-circuit. The test requirements of the circuit breaker and the application standard are determined by these decrement curves. A special working group under the chairmanship of R. L. Webb is making an intensive study of this problem. Utility engineers in the working group are checking numerous points on their systems having various operating voltages to determine how well the actual systems conform to proposed standard.

AIEE FELLOWS ELECTED..

Board of Directors Meeting, June 30, 1955

Harry Barker (AM '05, M '13), partner, Barker and Wheeler, New York, N. Y., has been transferred to the grade of Fellow in AIEE "for over half a century of active service to the electrical engineering profession as editor, educator, and consultant." Mr. Barker was born in Rutland, Vt., July 19, 1881. He obtained a bachelor of science degree in electrical engineering, cum laude, from the University of Vermont in 1904 and a doctor of engineering degree from the same university in 1954. From 1903–05 he was instructor at the University of Vermont. From 1904–07 besides working as instructor he was principal assistant to a consultant in Burlington, Vt., working on power station design. From 1907–17 he was associate editor and electrical and mechanical engineer for *Engineering News* and its successor *Engineering News-Record*. His principle assignment broadly related to significant developments in power generation, especially hydroelectric, and to the activities of the then new type of public service regulatory commission following the new laws enacted to start with in Wisconsin and New York, but rapidly followed in other states. Early in 1917 he was called to active duty as captain of engineers, U. S. Army. He had been commissioned in the original Officers Reserve in 1916. During his service with the U. S. Army he was engineer depot procurement officer, then cantonment utilities officer in charge of such services as light and power, central heating, water supply, sewerage and disposal, communications, roads, buildings, grounds, and fire department. Later he became an alternate for a member of the Pittsburgh Railway Valuation Board. He was honorably discharged in December 1919. Since 1919 he has been consultant, public utility regulation problems, with offices at Albany, New York, N. Y., and Montclair, N. J., when consulting firm of Barker and Wheeler was set up. Its purpose is not only for consulting work on "public-utility regulation problems" but for a wide variety of design, supervision of construction, and improvement in operation for electric, power, water supply, communication, transportation and sanitation facilities of private utilities, municipal bodies and industrial concerns. In earlier days, prior to about 1930, with its utility holding systems, such work was for the less than largest ones which did not maintain highly-developed engineering departments. As the consolidations grew, Mr. Barker's work continued with the smaller and fewer independent units, but

Courtesy Underhill Studio, N. Y.

H. Barker

with special services on limited questions for some of the larger ones. The amount of work on valuations, depreciation studies, and refinancing became larger. Circumstances have always seemed to force his work into joint fields and instances where close combinations of electrical engineering with the mechanical and civil had to be handled. After the Vermont flood of November 1927, because of his activities for the Vermont Public Service Commission, on the invitation of the Governor and Commission, he organized the Advisory Engineers Committee on Flood Control and remained a member for its existence of about 3 years. During that time a study was made of all the storage and power possibilities of all the important rivers of the state. Where developments have been made, they have followed those earlier studies. This committee continued as engineering advisor in 1932 and 1933 for a Vermont public-works committee under the various Federal-aid national-recovery efforts which built some of the flood control and power development projects planned for the Winooski River Valley. From 1936–55 he has been advisory engineer to the Municipal Electric Utility Association of New York. From 1934–37 he was consulting engineer to the Department of Railroads and Telephones, Province of Alberta, Canada. In 1917 he was the author of Public Utility Rates, a treatise on the principles and practices of rate making. Mr. Barker has served on the AIEE Principles of Professional Conduct Committee (1942–52) and was chairman of the committee when the present code was evolved (1947–50). He also served on the Professional Group Coordinating Committee (1948–50).

Delmer Wallace Callander (AM '21, M '30) consultant engineer, Canadian Westinghouse Company, Ltd., Hamilton, Canada, has been transferred to the grade of Fellow in the AIEE "for contributions to the development of transformers, particularly large power units." Mr. Callander was born in North Gower, Ont., on January 4, 1887. He obtained a bachelor of science degree in electrical engineering from McGill University in 1911. From 1909 to 1912 he took an engineering apprentice course with the Canadian Westinghouse Company, Ltd. For 2 years, 1912–1914, he did electrical design work on d-c motors and generators. Then for the next 5 years he did electrical design work on industrial induction motors. During the years 1919 to 1921, he worked on the electrical and mechanical design of fractional hp motors. In 1921 Mr. Callander was made section engineer in charge of the transformer section, and for 22 years was responsible for the design of power and distribution transformers. During this period he was responsible for building some of the largest transformers in Canada at the time, such as the 46,500 kva, 60 cycle, for the Beauharnois Power Company, the Niagara Falls Development of Queenston, and the 25,000 kva, 25 cycle (3 windings), 230 kva transformer for Leaside for the Ontario Hydro-Electric Commission. In 1943 he was made division engineer working on power and distribution transformers. Since 1947 he has been engaged as a consultant, first on special assignments for distribution transformers and then in the engineering department. His responsibility in this capacity covers the design of all types of transformers—power, distribution, autotransformers, instrument, and current and step-type as well as induction-type regulators. He is currently working in the field of surge protection of transformers and the development of the complete sure-proof distribution transformers. In this regard he has been consultant to all the manufacturers of this type of equipment. He has been active in the Professional Engineering Association of Ontario since 1938. He is a member of the Hamilton Branch Engineering Institute of Canada, the Transformer Technical Committee of the Canadian Electrical Manufacturers Association, the Electrical Apparatus Section of the Canadian Electrical Association, and the Power and Distribution Transformer Committee of the Canadian Standards Association. He has served on the following AIEE committees: Executive Toronto Section (1936–44) chairman of the Hamilton Discussion Group (1937–42), and chairman of the Toronto Section (1942–3).

William David Cockrell (M '43), electrical engineer, special defense projects department, General Electric Company, Schenectady, N. Y., has been transferred to the grade of Fellow in AIEE "for contributions to the advancement of electric techniques resulting in practical industrial control systems." Mr. Cockrell was born in Tallahassee, Fla., September 2, 1906. He is a graduate of the University of Florida, 1928, from which he received his bachelor of science degree in electrical engineering. He has also taken General Electric Company training courses in general engineering, servomechanisms, and theoretical fire control. In 1928 he entered the employ of the General Electric Company as a test engineer. Two years later he accepted an assignment in the Control Division as one of a four-man team specializing in electronic control engineering. His activities during this time were directed toward the incorporation of electronic techniques into practical control systems. From this connection came an array of new products destined to take prominent places in the progressive field of industrial electronics. These products included a variety of offshoots from photoelectric control such as photoelectric controlling pyrometers, edge alignment and cutoff register control as applied to sheet rolling and printing operations, photoelectric pinhole detectors used for locating defects in sheet material such as tinplate and paper, mercury-vapor detectors, and many others. He pioneered the development of the photoelectric template follower for flame-cutting machines. For his outstanding work in promoting the advancement of electronic techniques in the field of industrial control he received the Coffin Award from the General Electric Company in 1942. Another significant development which was made by Mr. Cockrell during this period included basic saturable core reactor grid shift circuits for application to Thy-mo-trol motor control. Under his direction was developed the specialized electronic input control used for precision control of large theatrical lighting installations such as that found at the Metropolitan Opera in New York, the Maple Leaf Gardens in Toronto, and the Teatro Nacional in Mexico City. In 1942 he transferred to the industrial engineering department of the General Electric Company. Intricate electronic control systems were being developed to speed up the processes of paper making, rolling steel sheet, and operating automatic machine tools of other characters. During these years Mr. Cockrell was extremely active in producing published technical data and educational programs which were essential in expanding the numbers of persons having a working knowledge of industrial electronics. He edited a 12-session slide film training course on industrial electronics and prepared and initiated special technical training courses for personnel within the industrial engineering department. He wrote a technical book, "Industrial Electronic Control." He also applied his special knowledge of electronics to aid in solving the special problems encountered in the war effort. In 1943, he participated in preparing and presenting a concentrated course on mass spectrometers for a group of engineers entering atomic work under the late George Brooker. Mr. Cockrell, with the assistance of associated engineers worked out a successful system of regulated power supply for the magnetic separation of U-235, a part of which was conducted at the University of California. He applied his special electronic understanding to the war work at Oak Ridge and the Argonne phases of atomic projects. He has also been active in the developmental work of the guided missile program in which the expert application of electronics plays a vital part. Mr. Cockrell in 1948 concentrated his energies in one field of industrial application engineering—that associated with the incorporation of adequate electrical brains and brawn to the productive machinery used in industry. His work in this field has implemented the development

D. W. Callender

W. D. Cockrell

of two- and three-dimensional electronic contour following machine tool equipments which has tremendously extended the output capabilities of precision machine tools. He assumed engineering responsibility for high-voltage electronic applications to the field of electrostatic precipitation, paint spraying, and material deposition. His thinking led to new basic designs for electronic differential hydraulic leveling of large industrial presses, the extension of automation in electric drill-press operation, and the development of servo-drives for milling machines, band saws, etc. When the technical knowledge associated with servo- and closed-cycle control systems was released from Government security classification in 1946, Mr. Cockrell, assisted by other engineers, developed a technical training course for application engineers in the industrial engineering department of the company. He also wrote the text material for the servo-section to be incorporated in the creative engineering program of the company. In 1952, Mr. Cockrell assumed the position of electrical engineer in the guidance engineering subsection of the guided missiles department. In his present assignment, he is engaged in directing the development and application of highly intricate electronic systems for application to guided missiles.

William David Coolidge (AM '10, M '34), x-ray consultant, General Electric Research Laboratory, Schenectady, N. Y., has been transferred to the grade of Fellow in the AIEE "for notable research and scientific achievement in electrical engineering, particularly the drawing of tungsten and in the development of the x-ray." Dr. Coolidge was born in Hudson, Mass., on October 23, 1873. He obtained a bachelor of science degree in electrical engineering from Massachusetts Institute of Technology in 1896, and a doctor of engineering degree in 1899 from Leipzig, Germany. From 1899–1904 he did post-graduate work at MIT. He joined the General Electric Company, Schenectady, N. Y., in 1905. His career has included the following positions in the research laboratory with this firm: research worker, 1905–8; assistant director, 1908–14; associate director, 1928–32; director, 1932–40; director and vice-president of company, 1940–50; director emeritus and x-ray consultant, 1950–55. Dr. Coolidge achieved international distinction in producing ductile tungsten and then expanding the utility of this new important material. His work led to the adoption of tungsten for ignition contacts. He made application of tungsten as the target for an x-ray tube, developed a method of vacuum casting a block of copper around a small tungsten target for the purpose of conducting heat away from the active target, and found other uses for the material. During World War I, Dr. Coolidge became famous through his inventions and developments in the field of submarine detection, and in developing small portable x-ray equipment for use at field hospitals near the front lines. During recent years he has done creative work in finding peace-time uses of atomic energy. In 1940 he accepted membership in the National Inventors Council. He became affiliated with the atomic bomb project and was appointed to a committee to evaluate the military importance of the uranium problem. In 1946 he attended the first Bikini test as a special observer. In the fall of 1945, in connection with the 50th anniversary of Roentgen's discovery of the x ray, he made a tour of South American lecturing before university groups and x-ray societies. In 1947 Dr. Coolidge served as a member with a group of scientists sent to Japan by the National Academy of Sciences at the request of General MacArthur, to give advise concerning the reorganization of Japanese science and technology. Dr. Coolidge is the recipient of 15 special awards for his technical accomplishments; he is the holder of 83 patents for his inventions; he has honorary degrees from eight colleges. He has maintained active participation in 12 societies, is an honorary member in 20, and a corresponding member in three. He has served on the following AIEE committee: Electrophysics (1927–9), Edison Medal (1940–5), and Application of Electricity to Therapeutics (1941–6).

Alan Graeme Darling (M '44), retired from General Electric Company, general consulting engineering, Schenectady, N. Y., has been transferred to the grade of Fellow in AIEE "for his contributions toward improved efficiency and operation of large industrial power generating systems." Mr. Darling was born September 15, 1888 in Toronto, Ont., Canada. He attended Sibley College, Cornell University, from which he graduated with a mechanical engineering degree in 1911. He specialized in electrical engineering. After graduating from Cornell he joined General Electric as a test engineer. In 1912 he advanced to the power section of the power and mining department of the company. The following year, 1913, he accepted a position with the Great Northern Power Company. His first engineering assignments with this company consisted of a review and check of engineering plans for a 10,000 kw hydrogenerator addition to the Great Northern Power system. In 1914 the responsibility of assistant superintendent was assumed at which time his responsibilities were expanded to include supervision of operation and maintenance for the entire electrical system of the company. He became general superintendent in 1915. During the 3 years that he occupied this position, he supervised the engineering planning of an 80-mile 66-kv transmission system extension from Duluth to Hibbing, Minn. He rejoined the General Electric Company in 1918, the year that the United States entered World War I. Mr. Darling's services were loaned to the U. S. Coal Conservation Commission to assist in finding ways and means of conserving coal which was in critical short supply. In the Albany-Troy-Schenectady, N. Y., area alone, a reduction of 100,000 tons per year was achieved. At the conclusion of the war, he returned to the power and mining department of the General Electric Company. For the remainder of Mr. Darling's engineering career, he concentrated on the problem of extending and improving the electrical facilities in this country for generating, transmitting, and distributing electric power. Between 1918 and 1924 the scope of the power and mining department was all inclusive. By 1924, the size of the operation had become so large that it became necessary to divide it. One division, the industrial engineering department, limited its scope to the electrical problems encountered in industrial manufacturing establishments, as contrasted with electric utilities whose sole business was the manufacture and sale of electric power. In 1924 he became affiliated with the industrial engineering department. Most of his time was devoted to the problem of proper engineering balance of electrical generating stations as found within industrial manufacturing organizations. He devised methods by which the steam requirements of extraction-condensing steam-turbine generators could be more quickly evaluated. He made many over-all steam-balance computations aimed at achieving the optimum balance between steam and electric power in a particular industrial plant. The industrial electrical systems which received broad overall engineering scrutiny by Mr. Darling included some of the largest in the U. S., such as U. S. Steel Corporation, Tennessee Coal, Iron, and Railroad Company, Geneva Steel Company, Ford Motor Company, and many others, including paper mills. For many years he served the Ford Motor Company as a power engineering consultant. Mr. Darling has contributed much original thinking in devising methods of short-circuit current analysis in electrical systems and is the author of many technical publications dealing with this subject. During the past several years, he has been actively engaged in devising suitable techniques for short-circuit current analysis of d-c systems. A part of this work has been associated with resolving the behavior characteristics of rotating d-c machines.

W. D. Coolidge

A. G. Darling

René Dupuis (M '44), commissioner, Quebec Hydro-Electric Commission, Mon-

R. Dupuis

W. B. Fisk

C. I. Hendricks

treal, Quebec, Canada, has been transferred to the grade of Fellow in the AIEE "for contributions to the electric industry as engineer, author administrator, and educator." Dr. Dupuis attended St. Jean College, St. Jean d'Iberville, Quebec, Canada, from 1912–1919. He received a bachelor of arts degree from Laval University, Quebec, Canada, in 1919. He attended McGill University, Montreal, Quebec, Canada, and University de Nancy, France, graduating with a degree in electrical engineering in 1924. Dr. Dupuis is particularly well known for his achievements as an electrical engineer in the design and operating fields. He has also gained recognition as a technical author for his many articles and reports which have been published repeatedly in Canadian technical magazines. He is an author of an English-French dictionary of electrical words and terms which has been published in three editions. In 1924, he joined the Canadian Westinghouse Company in Hamilton, Ontario, Canada; he became affiliated with the Shawinigan Water and Power Company in 1926, where he worked in the electrical repairs department. In 1931 he transferred to the Quebec Power Company where he was made distribution engineer. During the 10 years that followed he became assistant superintendent, then superintendent of the power division, and later assistant general superintendent of the company and subsidiaries. Dr. Dupuis has contributed a great deal to the electrical engineering profession in Quebec. In 1942 he founded a school of electrical engineering at Laval University and became the first professor and the first director of the school. In 1947 he was awarded the title "professor emeritus." A year later he received the "Palmes d'Academie" (Academy Palms) from the French Government. In 1947 he took charge of the Beauharnois Hydro-electric Development as superintendent engineer, retaining this position when appointed as a Commissioner of the Quebec Hydro-Electric Commission. He is currently in charge of the 1,200,000-hp development at Bersimis, which has a 300 kv transmission line and is 400 miles long. He has also initiated the job of installing 60-kv cables, $31^1/_2$ miles long, under the St. Lawrence River near the Bersimis development. Dr. Dupuis is a member of the Corporation of Professional Engineers of the Province of Quebec; the Engineering Institute of Canada since 1930, where he served a term as chairman of the Quebec Chapter; the Canadian Electrical Association; the McGill Graduate Society, where he served as secretary; and the International Conference of Large Power Systems, in which he served as a director.

Walter Burton Fisk (AM '28, M '34), system engineer, Consolidated Edison Company of New York, Inc., has been transferred to the grade of Fellow in AIEE "for contributions to the design, installation, and operation of inside and outside plant in a large metropolitan electric system." Mr. Fisk was born in Montgomery, Ala., July 6, 1906. He is a graduate of Alabama Polytechnic Institute, class of 1927, where he obtained his bachelor of science degree in electrical engineering. He was employed by the Brooklyn Edison Company in June, 1927, in the inside plant bureau, electrical engineering department, as an engineering assistant. He became junior engineer and then assistant engineer. By July 1931 he was division engineer of the inside plant bureau responsible for and directing the work of a group of engineers performing general engineering studies relating to the design, maintenance, and operation of the company's generating stations and substations. Work during this period included engineering problems relating to two 160,000 kw tandem compound turbogenerators. In 1931 he was made assistant inside plant engineer of the Brooklyn Edison Company. His work was extended to include the direction of engineering activities in the Design and Drafting Division. Responsibility was for all engineering, design, and drafting required for the electrical work in generating stations, substations, and large customer installations. He became inside plant engineer in responsible charge of the bureau in March 1936. Two years later, March 1938, he was transferred to the inside plant bureau of the Consolidated Edison Company as an assistant division engineer after spending approximately $1^1/_2$ years as the district manager of the Brooklyn Edison Company. His work was of a general engineering nature, including relay protection, short circuit studies, determination of equipment standards and engineering economic studies. During this time he was in charge of field engineering and co-ordination of the technical problems required in the restoration of equipment in the company's Hell Gate Generating Station during the hurricane of 1938. He presented papers describing the solution of these problems before the Power Group of AIEE and the Electrical Equipment Committee of the Edison Electric Institute. In July 1940 he was made division engineer in charge of the Design Division of the inside plant bureau. He was directly responsible for the electrical design work in all generating stations and substations of the Consolidated Edison Company. In January 1943 he became assistant general superintendent in charge of underground cable construction for the company and in July 1944, distribution engineer of the Westchester Lighting Company. On this latter job he was responsible for the design of electrical distribution facilities in the county of Westchester. In October 1945 he became assistant outside plant engineer, Consolidated Edison. In this job he was assistant head of the bureau. His responsibility was for engineering relating to all elements of the company's outside plant system. This work included distribution system planning, design of underground cable systems, design of underground ducts and manholes, design of overhead distribution systems and determination of and preparation of equipment specifications. He became outside plant engineer in August 1948 and planning engineer for the company in May 1949. This latter job included responsibility for the determination of long-range plans for the development of the company's electrical system, including required time schedules for new capacity, the preferred location of additional generating facilities, and requirements for transmission between stations. It also included responsibility for the engineering economic evaluation of alternate basic plans of system development. Additional responsibilities were for the development and negotiation of all special power contracts relating to operations with other utility companies and electric railroads. Another activity covered in this assignment was the engineering determination of the most economical loading of the company's electric generating facilities. In June 1952 Mr. Fisk was appointed to his present position, system engineer for the company. He has direct responsibility for the direction of the planning functions described above and, in addition, the direction of engineering activities relating to the study of future electric load requirements, the determination of construction and operating requirements, and the development of engineering economic studies of various phases of operation of the company's electric business. His AIEE committee work includes: Transmission and Distribution (1946–49), System Engineering (1949–53), Education (1953–54).

Chester Irving Hendricks (AM '24, M '31), design engineer, Texas Electric Service Company, has been transferred to the grade of Fellow in AIEE "for contributions to the design of electric distribution systems." Mr.

Hendricks was born April 3, 1895 in Port Huron, Mich. He graduated from the Pratt Institute, June 1921, where he obtained a certificate in electrical engineering from the School of Science and Technology in Electrical Engineering. Immediately after graduation he worked for the Westinghouse Electric and Manufacturing Company's service department on construction work in connection with the initial installation of Hell Gate Steam Electric Generating Station of the United Electric Light and Power (Consolidated Edison) in New York, N. Y. From 1921–23 he was affiliated with United Electric as an engineering assistant in the transmission distribution department. He was associated with some of the early pioneer engineering of the "120/208 volt, 3-phase, 4-wire low-voltage network distribution system" which this company fathered. In 1923 he joined New Orleans Public Service, Inc., Louisiana, attached to the distribution engineering department in the position of underground system engineer. During the time he was employed by this company, the underground system, which consisted primarily of a 120–240 volt d-c network, was being rehabilitated. He was in charge of design, planning, construction, and making engineering decisions. Concurrent with this reconstruction of the underground system of the company, a 120/208 volt, 3 phase, 4 wire low-voltage underground network distribution system, employing a 13.2 kv primary source, was installed parallel to the then existing Edison 120–240 volt d-c system. Upon the completion of the initial portion of this network system, which was designed and constructed by a private engineering firm working with the company, the responsibility of continuous engineering planning and operation of the system was under the competent charge of Mr. Hendricks during his stay with the New Orleans Public Service, Inc. From 1929–30 he was employed by the Electric Bond and Share Company (Ebasco Services, Inc.) of New York, N. Y., as an assistant electrical engineer assigned to engineering duties with the Fort Worth Power and Light Company, Texas. (Texas Electric Service Company) and Pennsylvania Power and Light Company, Harrisburg, Pa. The Fort Worth assignment was as resident engineer in a consulting capacity during the time that a 120/128 low-voltage network system, which had previously been designed, was being installed. The Harrisburg assignment was for the purpose of designing, planning, and acting in a consulting capacity during the installation of a 120/208 volt, 3-phase, 4 wire underground network distribution system which supplanted the radial distribution system which had been used to serve the downtown area of this city. The last 25 years of Mr. Hendrick's career have been spent in the general office engineering department of the Texas Electric Service Company in Fort Worth as chief electrical design engineer in responsible charge of design and construction of all electric substations and underground distribution engineering. During the early part of this period he promoted the idea of 12.5 kv primary voltage for urban overhead distribution, which was finally accepted in 1937. With the introduction of this distribution voltage, a particular type of substation was designed for use in the Fort Worth area. The station is essentially of two parts, made up of: (1) a structural steel trussed beam and column type of open structure for the 66 kv primary and transformer section, and (2) outdoor metal-clad retractable type of switchgear for the 7,200/12,470-volt wye low voltage side. Contrary to commonly accepted practice, the substation uses only a single 12.5-kv bus, relying entirely upon adjacent substations for carrying the load during emergency periods. A similar design, known substantially as a "factory designed and constructed type" later became popular in the electric utility industry. The station is controlled via supervisory means from the local distribution dispatcher's office, and facilities are also provided for telemetering indication of the substation total kw load reading to the same office. Since the first station installation, a total of eight have been designed and constructed in the Fort Worth area, with an aggregate transformer capacity of 250,000 kva. Along with the design of these substations, much engineering progress has been made, directly or jointly with equipment manufacturers' engineers, including: (1) supervisory control using wire or carrier channels; (2) telemetering and load control using wires, carrier, or microwave channels; (3) carrier-relaying distance and phase comparison type; (4) control circuit design for "air circuit-breakers fuse co-ordination" associated with 12.5 kv distribution circuits provided with co-ordinated primary fused laterals. In connection with the expansion of the Fort Worth 120/208 volt low voltage underground network, Mr. Hendricks has to a large degree been responsible for the use of askarel, class "B" open dry type, class "H" open dry type, and class "H" sealed gas type of 3-phase network transformers. A particular type of fusing arrangement has been developed for use on this system to provide individual fusing to all large buildings as a means of precluding the possibility of failure of network protector fuses in cases of non-clearing faults in the customers' wiring. This network system has completed a 25-year service record without a total or partial system shut-down due to any network distribution system cause. Mr Hendricks served on AIEE's Substations Committee (1953–55).

Ray Albert Larner (AM '26, M '38), meter and relay engineer, Texas Electric Service Company, Fort Worth, Tex., has been transferred to the grade of Fellow in AIEE "for his contribution in the field of relaying and metering as applied to a far-flung power system." Mr. Larner was born February 6, 1895, in Morgan Mill, Tex. He obtained a bachelor of science degree in electrical engineering from Oklahoma A & M in 1920, a master of science degree in electrical engineering in 1927 and a professional electrical engineering degree in 1948, both from Union College, Schenectady, N. Y. In 1920 Mr. Larner took the test course at the General Electric Company, Schenectady, N. Y., following 2 years military service in World War I. In 1922 he worked in the company's District Office in Dallas. For 6 years, 1924–30, he was an electric utility construction test engineer where he was given the responsibility of inspecting and testing new electrical equipment for the Texas Electric Service and and Texas Power and Light. During the first few months with this company, he developed and built a 3-phase phantom loading device for positively establishing the correct direction of directional relays on high-voltage transmission line terminals before being placed in service. This equipment simulated loading on high-voltage breakers before being placed in operation. It proved not only most useful for directional relays but also highly useful to check current and potential transformer relations, correct indications of wattmeters, varmeters, watt-hour meters, etc. When the Texas Electric Service Company was established as an operating company with headquarters in Fort Worth in 1930, he was transferred to the power department with the title of chief meter and relay engineer. Mr. Larner has made important contributions to the advancement in the art of transmission and distribution systems, relaying, control, and service improvement by devising and applying new ideas in relaying schemes and the reclosing of circuits. Original work since World War II have included improvements in telemetering applications and pilot wire relaying, a rebuilding program for high-voltage circuit breakers, development and use of portable direct writing oscillographs for staged testing, use of portable d-c, short-circuit calculating boards, and other achievements. Mr. Larner assisted in the organization of the Texas A & M Annual Conference for Protective Relay Engineers in 1947 and is a member of its Program Planning Committee. He has served on the following AIEE committees: National Protective Devices Committee (1938–40), first chairman of the Fort Worth Subsection (1946–7), Executive Committee (1946–8), and the Relay Committee (1948–55).

Rhea-Engert photograph

R. A. Larner

Russell McLeod Laurie (AM '21, M '30), manager, Western Region, Hydro Electric Power Commission of Ontario, London, Ontario, Canada, has been transferred to the grade of Fellow in the AIEE "for development of interconnected pool operation of large electric power systems on an international scale." Mr. Laurie was born in 1899 in Woodstock, Ont. He received his bachelor's degree from the University of Toronto in 1924. During summer vacations from 1920–24, he was employed by the Ontario Hydro Electric Commission at the Sir Adam Beck Generating Station No. 1, Niagara Falls, Ont., carrying out electrical construction on the main generators and auxiliaries. Upon graduation from the University of Toronto, he was appointed assistant chief operator of the Sir Adam Beck Generating Station No. 1, an hydraulic plant of 500,000-hp capacity in ten units.

R. M. Laurie

After the decision by the Ontario Commission in 1927 to form a load supervising office at Niagara Falls, he was appointed chief load supervisor and organized and supervised the first such load control center. He engineered and completed the first interconnection within Ontario and also the first international power pool. This latter was done in collaboration with another AIEE Fellow, H. L. Harrington of the Niagara Power Corporation, N. Y. This was very much in the nature of a pioneer effort and required the engineering of special instrumentation and the adaptation of then existing control equipment for the operation of this large interconnection. From 1932–38 this power pool was used effectively to obtain maximum use of the Commission's hydraulic resources with the steam generation of the Niagara-Hudson Corporation. In order to do this, considerable engineering planning, without the assistance of modern a-c calculating boards, was carried out to permit the optimum use of international diversions by load tranfers from less efficient to more efficient generating stations during the entire 24-hr periods. As a result of this international power pool, many millions of dollars were saved in power costs to both participating organizations. During 1938 the Ontario Power Plant on the Niagara River, with a capacity of 160,000 hp, fifteen units, was completely flooded with ice-filled water and Mr. Laurie was in responsible charge of the rehabilitation of the plant, carrying out a successful large-scale dry-out experiment by the use of vacuum and heat. From 1938–42 he was operating superintendent, Niagara System, Ontario Hydro, which at that time was the largest interconnected system in Canada. It was necessary to put this system on a war emergency basis by engineering planning and physical rearrangement. This, to a large extent, was aided through engineering studies on the a-c calculating boards at Pittsburgh, Pa., and Schenectady, N. Y. Because of war conditions causing an unprecedented load demand, together with lack of new generating sources, and because of the necessity of a central point for co-operation with the War Production Board in Washington, D. C., the Ontario Commission approved the formation of a Power Supervising Office in Toronto. The purpose of this office was to co-ordinate the entire resources of the Commission in the Province of Ontario together with purchased power from the Province of Quebec. Mr. Laurie was appointed power supervising engineer. This again required co-operation with manufacturers in the development of instrumentation for load control, telemetering, etc. Co-operation, under the direction of the Canadian Power Controller with the War Production Board, Washington, was of primary importance on the interchange of power and the creation of power pools for the allocation of all available energy for war industry. In 1945 with the co-operation of the Niagara-Hudson Corporation one of the largest interconnections in North America was carried out, tying together 11,200,000 kw capacity. The area affected was western Quebec, southern Ontario, the northeastern United States, and south to Maryland. During this period, he was chairman of the Load and Capacity Committee for the Study of Postwar Development. In 1947 he was in charge of post-graduate lectures at the University of Toronto, preparing and delivering Lecture No. 18, "The Operation of a Large Power System." Upon the decentralization of Ontario Hydro he was appointed manager of the Western region with headquarters in London, Ont. He was responsible for all maintenance, operation, construction, and management, including accounting and personnel. The region consists of a staff of 1,200. Twenty-five areas are operated; 74 municipalities supervised; approximately 12,000 miles of lines, from 4,000 to 230,000 volts on poles and steel towers maintained; and 100 distributing stations, 16 transformer stations, one 100,000 kva frequency changer station and a 264,000 kw modern steam generating station—875 lbs. pressure, 900 F, 3,600 rpm—operated. From 1947–48 he served on AIEE's System Engineering Committee.

L. G. Levoy

Louis George Levoy (AM '31, M '43), power systems engineer, industrial engineering section, General Electric Company, Schenectady, N. Y., has been transferred to the grade of Fellow in AIEE "for his contributions to and development of electronic control, welding circuits and electric equipment for aircraft." Mr. Levoy was born March 18, 1907, at Webster, S. Dakota. He attended the University of California, Berkeley, where he obtained a bachelor of science degree in electrical engineering in 1929. He has also taken training courses given by the General Electric Company as well as courses in advanced engineering and business management. After graduation Mr. Levoy was employed by General Electric in the test engineering program. While working in this program, he accepted assignments in departments which included the following types of equipment: large motors and generators, steam-turbines, induction motors, transformers, switchgear test station operation, and high-voltage laboratory experience. Two years later he was transferred to a special engineering training program which consisted of a series of special engineering assignments in a number of operating departments which included induction motor design engineering, the research laboratory, switchgear test, electronic control, and general office application engineering. Following this training period he accepted a position with the industrial control engineering department of General Electric. His work was devoted chiefly to product refinement and advancement, particularly in equipment incorporating electronic control systems. He invented and developed many electronic techniques in the field of welding control and did original developmental work in connection with energy storage welding circuits using electronic tubes. He has obtained patents covering special peaking transformer circuits which form an important part in the control of thyratron electronic circuits. Also, he developed and promoted a practical series capacitor welder using electronic control means. One of his important contributions which made this device successful was an automatic, electronic control circuit which turned on the welder at crest voltage during the half cycle—the polarity of which matched that of the charge remaining on the series capacitor from the previous spot weld. Most of Mr. Levoy's patents were acquired during this assignment with the industrial control engineering department. In 1940 he was advanced to industrial power application engineer in the Industrial Engineering Division where he was responsible for selecting and applying large-scale power components, such as circuit breakers, transformers, busses, cables, protective relays, etc., to industrial power electrical distribution systems. During World War II Mr. Levoy accepted an assignment on a special engineering development program the object of which was to explore and rationalize the operating behavior of helicopter rotor blades. He also worked on developing improved electrical designs of power systems for large aircraft, working closely with Army Air Force technical personnel at Wright Field. He was directly responsible for major contributions to the development of practical 400-cycle a-c aircraft electrical systems. He also organized and operated an aircraft armament training school for field maintenance personnel. At the conclusion of World War II activities, he was offered the position of application engineering in the paper and textile industry section at the General Electric Company. These industries were among those whose development programs were artificially curbed during the war years. After the war they were confronted with expanded postwar demands which assumed staggering proportions. The development of faster, more precise processing machines was the prime problem of the day. It was Mr. Levoy's job to devise adequate stable regulating and control systems for these speedier machines. In addition to doing the planning engineering of electrical components in the design stages, he was many times called upon to supervise the installation and commissioning of these complicated high-speed equipments in pur-

G. L. Oscarson

C. E. Scholz

H. R. Sills

G. O. Watson

chasers' plants in foreign countries, as well as in the United States. From 1950–52 he was liaison engineer at the Knolls Atomic Power Laboratory. His duties and responsibilities concerned the adequate interchange of engineering knowledge between the Knolls Atomic Power Laboratory, the Atomic Energy Commission, and the Navy Bureau of Ships. In 1952 he completed his assignment at the Knolls Atomic Power Laboratory and returned to the General Electric Company in his present position. His responsibilities involve the supervision of application engineering in the company as applied to the steel mill industry.

Gerhard Lionel Oscarson (AM '24, M '30), chief application engineer, Electric Machinery Manufacturing Company, Minneapolis, Minn., has been transferred to the grade of Fellow in AIEE "for engineering development and co-ordination of the design of rotating electric machinery to the changing requirements of industry and national defense." Mr. Oscarson was born April 27, 1900, in Wheaton, Minn. He obtained his bachelor's degree in electrical engineering from the Minnesota Institute of Technology in 1922 and the degree of electrical engineer from the same institution in 1954. He joined the Electric Machinery Manufacturing Company, Chicago, Ill., as application engineer in 1923. Among other assignments, he made original analytical and experimental studies of electrical and mechanical factors involved in motor drives for nonferrous metal cold rolling mills, resulting in recommendation for installation of synchronous motors for this service—the first known application of this type still in successful service. In 1927 he went to St. Louis, Mo., as application engineer for the company where he had full responsibility for application engineering, southwestern district. Along with general problems of application of electrical power apparatus to industry, he made original studies on: application of relatively small a-c generators for combined lighting and power service, establishing procedures for practical determination of limitations for satisfactory operation, since widely followed; analysis and establishment of design characteristics, for application of gas engine driven alternators as power supply for submersible type pump motors widely used in oil industry, involving original arrangements of generator windings and excitation system, plus novel procedures for operation to accomplish successful results; studies and establishment of design characterisitics for fully automatic, multiple unit, gas engine driven generating stations, providing isolated electrical power supply for oil field pumping units. (These studies embraced prime movers, governing systems, load characteristics and control systems as well as electrical characteristics of generators.) In 1940 he became chief application engineer in Minneapolis, Minn. He was responsible for application of equipment to industry needs, serving as consultant to sales negotiation, electrical design, mechanical design, control design, and development engineering departments. He established electrical and mechanical design criteria for first successful installation of synchronous motor driving multiple knife large log chipper for paper industry. These design features were generally followed by other manufacturers on later installations. He was selected as a member of the Subcommittee on Power Requirements for Chippers by the Technical Association of Pulp and Paper Industry and developed formula approved by this committee in selection of synchronous motors for this service. He is currently serving as member of the Electrical Engineering Committee for this Association. Mr. Oscarson also established design requirements for utilizing high-pressure air from ventilating blower on 3,600 rpm motors as an aerodynamic seal to exclude oil vapor from motors. He also pioneered application of "Monocoil" type 180- to 360 cycle a-c generators as power supply for high speed electrical tools, developing new standards of electrical performance, and collaborated in development of specifications for utilization of this new design by the Armed Forces. And, he developed formulae and constants for correct application of "Incher," widely used on large synchronous motor applications in cement and ore reduction industries for precise positioning of driven equipment, utilizing pullout characteristics of the synchronous motor for developing high torques at very low speeds. Mr. Oscarson is the author of many papers appearing in the technical press. Among his papers appearing in AIEE publications are: "Telephone Influence Factor in Synchronous Machines," *Electrical Engineering*, vol. 70, 1951; "A-C Motors and Controls in Refineries and Pipelines," *Applications and Industry*, November 1954. His article "ABC of Large Induction Motors," has been used as supplementary application text for senior power students at the University of Utah, Villanova, University of Manitoba, Worcester Polytechnic Institute, and other electrical engineering schools. He was granted an advanced degree in Electrical Engineering by the University of Minnesota, June 1954, in recognition of "attainment of professional competence and judgment."

Carl Eugene Scholz (M '26), vice-president and chief engineer, American Cable and Radio Corporation, Mackay Radio and Telegraph Company, Inc., All America Cables and Radio, Inc., and The Commercial Cable Company, New York, N. Y. Mr. Scholz was born November 29, 1894, in Campbell, Calif. He obtained his bachelor of arts degree in mechanical engineering in 1917 from Stanford University, Calif. That year he was employed by the Federal Telegraph Company, Palo Alto, Calif., doing drafting and design work. The following year he transferred to the engineering department where design calculations for high power arc radio transmitters and general engineering office work was done. He worked on the design of an antenna system for the U. S. Navy Department's long wave high power radio station at Annapolis, Md., including calculation of sags and tensions of the antenna conductors under various assumed conditions of wind and ice loads and means for removing ice when it formed on the antenna conductors. That same year he assisted in installation of radio equipment including power supply and switchboard equipment and conducted acceptance tests. In 1919 he transferred to Puerto Rico to take charge of installation and acceptance tests of 200 kw arc radio transmitter at the U. S. Navy Department's long wave, high power radio station at Cayey, Puerto Rico. Also, he designed and supervised erection of the antenna system for this station. He returned to the engineering department in Palo Alto, Calif., where he was assigned to engineering problems in connection with design and construction of 100 kw arc transmitting equipment for the Navy Department's station at Guam. He assisted in the planning and design of the transmitting and receiving stations of Federal Telegraph Company's radio communication system with stations at Los Angeles, San Francisco, and Portland, Oreg. He supervised design of equipment station and building plans, antenna and ground systems, water supply systems, and later general supervision of the construction and installation work which was completed during the early part of 1922. In 1922 he supervised installation of 100 kw arc radio transmitter with harmonic suppression circuit and uniwave signaling system at the Navy Department's radio station, Mare Island Navy Yard, Calif. For about a year he was in charge of the engineering department during the absence of

the chief engineer and was responsible for all activities of the engineering department, including design and manufacture of all equipment. His appointment as chief engineer of the Federal Telegraph Company came in 1924. He was responsible for all engineering and development activities of the company, including design and manufacture of all equipment and the maintenance of radio stations of the company's communication system. Two years later he was appointed chief engineer of Brandes Products Corporation, Newark, N. J., responsible for development, design, inspection, and test of broadcast receivers and associated equipment on a quantity production basis. He continued to give general supervision to engineering activities of Federal Telegraph Company until 1928 at which time he resigned as chief engineer of that company to devote full time to position of chief engineer, Brandes Products Corporation. In 1929 he entered the employ of International Telephone and Telegraph Corporation, New York, N. Y., as engineer in the radio operating department. He was sent to Lima, Peru, in complete charge of construction for All America Cables and Radio, Inc. of short-wave radio transmitting and receiving stations for telegraph service to the United States. From Lima he transferred to Rio de Janeiro, Brazil, in 1930. There he was engineer in charge of the construction for the Companhia Radio Internacional do Brasil, and International Telephone and Telegraph Corporation, subsidiary company of short-wave radio transmitting and receiving stations and central office for radio telephone service between Rio de Janeiro and New York, Buenos Aires, Argentina, and Madrid, Spain. In 1931 he returned to the engineering department in New York where he had direct supervision of drafting and design for International Telephone and Telegraph Corporation, radio operating department, and Mackay Radio and Telegraph Company. In 1936 he was elected vice-president of the Radio Corporation of Porto Rico, subsidiary of the International Telephone and Telegraph Corporation, responsible for all engineering matters for that company. He transferred to the Mackay Radio and Telegraph Company as assistant to the vice-president and chief engineer in 1940. Five years later he was elected vice-president and then also assisted in the general administrative matters of the company. He was acting chief engineer of Mackay Radio and Telegraph Company during the absence of the vice-president and chief engineer in 1947. In 1950 he became vice-president and chief engineer of the company, the same year that he became vice-president and chief engineer of All America Cables and Radio, Inc. and The Commercial Cable Company. In 1951 he became vice-president and chief engineer of American Cable and Radio Corporation. In his present position as vice-president and chief engineer of the American Cable and Radio Corporation and its three principal subsidiary operating companies, he is responsible for administration and direction of all engineering and development activities for both cable and radio systems, as well as assisting in the general administrative matters of the company.

Mr. Scholz has been a member of the Institute of Radio Engineers since 1926, and a senior member of that institute since 1943. He is a registered professional engineer in both New York State and California.

Hubert Ryerson Sills (AM '24, M '31), supervisor, design engineering, Canadian General Electric Company, Ltd., Peterborough, Ont., Canada, has been transferred to the grade of Fellow in the AIEE "for his contribution to the design of large hydroelectric generators." Mr. Sills was born in Kingston, Ont., in 1900. He obtained a bachelor of science degree in electrical engineering from Queen's University, Kingston, Ont. His work in the design engineering field has been directly concerned with the design of synchronous machines, particularly water-wheel driven vertical-shaft generators and large synchronous condensers for the Canadian General Electric Company, Ltd. In 1921 he took a test course with this company and for the next 24 years was a design engineer in the a-c engineering department. In 1945 he obtained the position of assistant division engineer in this department. Seven years later he was made senior engineer and worked with synchronous machines in the engineering section, motor and generator department. A year later he became supervisor in design engineering with a-c machines. Mr. Sills has designed or has been responsible for the design of generators for most of the hydraulic generating stations in Canada as well as a number in foreign countries. He was responsible for practically all of the largest hydroelectric power developments in Canada, which include Shipshaw, many Ontario Hydro-Electric Power Commission stations (including Sir Adam Beck No. 2), the Kemano Development, the La Tuque and La Trenche stations of the Shawinigan Company, and others. The developments mentioned are all large having 75,000- to 80,000-kva capacities. His design work and responsibility covers large synchronous motors for pulp grinding and pumping applications, and large outdoor hydrogen-cooled, outdoor and indoor air-cooled, synchronous condensers. The designs of all these machines have been characterized by unique ventilation and structural arrangements that have provided significant benefits in improved cooling. Mr. Sills has been active in the Engineering Institute of Canada since he joined in 1921. From 1940 to 1945 he was a Counsellor of the Institute, and since 1945 he has been chairman of the Membership Committee. In 1950 Mr. Sills was appointed chairman of the Canadian Section Study Committee No. 17 for the International Conference on Large Electric High-Tension Systems. In municipal affairs in the city of Peterborough, he has been a member of the City Planning Board since 1947, and chairman of the Board since 1953. He has served on the following AIEE committees: Electric Machinery (1934–55), Power Generation (1936–8), and Rotating Machinery (1949–55).

George Oliphant Watson (M '45), principal electrical engineer surveyor, Lloyd's Register of Shipping, London, England, has been transferred to the grade of Fellow in AIEE "for his accomplishments in the application of electricity to ship propulsion and in the formation of the regulations governing electrical installations on shipboard." Mr. Watson was born in London, May 14, 1891. His education was obtained at Battersea Polytechnic, London, where he received a diploma in electrical engineering in 1910. In 1911 he joined the British Thomson Houston Company, Ltd., as design engineer doing general design of starters, rheostats, and research. From 1916-21 his work was extended to include development of oil-immersed starters and production lines of starters, resistances, and brake magnets, and control gear for rolling mills, mine winders, and electric traction. From 1921-33 he had complete responsibility for development and design of control gear and switchgear for electric ship propulsion schemes for all ships equipped by the company. This period was one of pioneering in the application of electric propulsion to ships on a commercial scale and included the first use of synchronous motors for this purpose. He also supervised the final stages of installation, including the conducting of dock trials and sea trials. Among the notable ships for which he was responsible were: San Benito (one of the first to be fitted with synchronous motor drive) La Playa, and La Marea (among the first successful cargo ships to be fitted with diesel electric 4-engine propulsion), Brunswick, Permian, Winkler, Musa, Platano, Darien, Viceroy of India, Rangatira, Strathaird, and Strathnaver. During this period 19 British patents were granted, three of which were also patented in the United States, Italy, and Belgium. In 1933 he joined Lloyd's Register of Shipping as senior electrical engineer surveyor. The following year he drafted Lloyd's Register's first rules for electric propulsion of ships which were subsequently adopted as the basis for the Institution of Electrical Engineers' (IEE, British) regulations. He became principal electrical engineer surveyor for Lloyd's in 1936. He is responsible for analyzing and approving plans for electrical installations in all ships built for Lloyd's Register of Shipping Classification and for the preparation of the rules and standards governing such installations—including the survey requirements for equipment during construction and service. This includes approximately 65 per cent of world shipping under construction at the present time. Since 1939 he has been chairman of the IEE Committee for the preparation of regulations for the electrical equipment of ships and since 1947 chairman of the International Electrotechnical Commission Technical Committee No. 18, electrical installations in ships. He has been chairman of the British Standards Institution (BSI) Committee on Electric Cables and a member of many other BSI committees. He is a past president of the Institution of Engineering Inspection (1941–43) and a member of the Council of the IEE and a past chairman of the Utilization Section of that Institution. In 1948 he was a delegate to the Safety of Life at Sea Conference. He is the author of "Trends in the Application of Electricity in British Ships" (IEE Journal, vol. 86, 1940) and delivered the eighteenth Thomas Lowe Gray lecture to the Institution of Mechanical Engineers (British) in 1946. entitled "Recent Developments in Alternating-Current Turbo-Electric Ship Propulsion." From 1945–54 he served on AIEE's Committee on Marine Transportation.

AIEE PERSONALITIES.....

James F. Fairman (A' 20, M '27, F '35), vice-president in charge of engineering, Consolidated Edison Company of New York, Inc., New York City, has been elected as Honorary Member of the AIEE. Dr. Fairman will be presented the Honorary Membership Certificate at either the Fall General Meeting in Chicago or the Winter General Meeting of 1956 in New York. Dr. Fairman was born in Big Rapids, Mich., on April 8, 1896, and received a bachelor of science degree in electrical engineering in 1918, and a master of science degree in 1921, both from the University of Michigan, Ann Arbor. Upon completion of a graduate course at the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., he returned to the University of Michigan and served as instructor in electrical engineering. In 1922 he was appointed assistant professor. In 1925 he joined the Brooklyn (N. Y.) Edison Company as an assistant outside plant engineer. In 1926 he became a full-fledged outside plant engineer, and later in the same year assistant electrical engineer. He was appointed electrical engineer in 1932, and following the merger of various predecessor companies into Consolidated Edison Company of New York, Inc., in 1936, he became electrical engineer for the system. Dr. Fairman was appointed assistant vice-president for design, inventory, purchasing, and stores in 1941, and 4 years later was elected vice-president in charge of electric and gas production and operation. He was appointed Administrator, Defense Electric Power Administration (DEPA), August 1951, and honored with the Interior Department's Distinguished Service Award citation in recognition of his accomplishments as head of DEPA in January 1953. He returned to Consolidated Edison later in 1953 and in June was awarded the honorary degree of engineering by the University of Michigan. Dr. Fairman is currently in charge of development of Consolidated Edison's Atomic Power Project; he is the Director of Atomic Power Development Associates, Inc., and a member of the Executive Committee. He has served on the following AIEE committees: Education, 1941–42; Electrical Machinery, 1936–37; and General Power Applications, 1934–36. Further, he has been Chairman of the New York Section, 1940–41, Vice-President of the Institute, 1944–46, Director, 1946–49, and President 1949–50. He has served on many general committees, including: Board of Examiners, 1941–44; Technical Program, 1941–42 and 1945–47; Executive, 1944–47; Finance, 1944–46; Safety Codes, 1931–34; and Institute Publicity, 1946–47. He has been a member of the Committee on Planning and Co-ordination since 1945, and was Chairman, 1945–47, when the study of organization was one of its major projects. In addition to this, he is a member of the special committee on Institute dues, and of the Edison Medal Committee for the term 1947–49. Dr. Fairman served as AIEE representative on the Engineers' Council for Professional Development, 1938–44, and has been representative on the board of trustees, United Engineering Trustees, Inc., since 1947, being a vice-president at present He has been equally active as a member of the National Society of Professional Engineers, beginning in the Kings County Chapter where he was president for three terms, followed by two terms as president of the New York State Society, 1942–44. He served as director of the national society, and two terms as vice-president for the Northeastern area, 1946–47. The author of a number of papers on professional subjects which have appeared in the *American Engineer* and *Electrical Engineering*.

G. W. Dunlap (AM '35, F '48), manager of the instrument and nuclear radiation engineering services department, General Electric Company, Schenectady, N. Y., is on leave from General Electric while serving as visiting professor during this academic year at Massachusetts Institute of Technology (MIT). Dr. Dunlap is the third distinguished engineer to hold the Edwin Sibley Webster Professorship of Electrical Engineering, established by a $400,000 grant in memory of Mr. Webster, who, with his MIT classmate, Charles Stone, founded the consulting firm of Stone and Webster, Inc. A native of Nevada, Dr. Dunlap did his undergraduate and graduate work at Stanford University and has been on the General Electric staff since 1936. During World War II he was assigned to the Manhattan District and made important contributions to the atomic bomb in connection with the production of Uranium-235. Since the war he has participated in development of cyclotrons, synchrotrons, particle accelerators, and radiation and electronic instruments. At MIT, he will conduct a graduate course, give formal lectures, and make important contributions through consultation on research and guidance in plans for the department as they bear on new efforts related to energy conversion and exploration of solid state devices—such as transistors, solar batteries, and magnetic amplifiers. He is a member of the American Physical Society and a charter member of the American Nuclear Society. In 1942 he was awarded AIEE's Alfred Noble Prize.

J. F. Fairman

G. W. Dunlap

F. E. Terman (AM '23, F '45), dean of the School of Engineering, Stanford University, Stanford, Calif., has been appointed provost of the university. Dr. Terman, will also continue as engineering dean. Dr. Terman took office September 1 and is now the second ranking administrative officer of the university with responsibilities primarily in academic affairs. He will act for the president when the president is absent from the campus. This is his 30th year on the Stanford faculty. After receiving his doctor of science degree at Massachusetts Institute of Technology (MIT), he was appointed electrical engineering instructor in 1925. In 1937 he became a full professor and head of the Electrical Engineering Department, and in 1945 dean of the School of Engineering. On leave during World War II, he headed the radio research laboratory set up at Harvard University by the Office of Scientific Research and Development with a staff of 800. The laboratory was the chief United States agency developing radar countermeasures. He was decorated by the British Government in 1946 and received the Medal for Merit, highest U. S. civilian award in 1948. Dr. Terman was elected to the National Academy of Sciences in 1946. He was graduated by Stanford, first in his class in 1920, and obtained the engineer degree in electrical engineering before beginning his doctoral work at MIT. Harvard and the University of British Columbia have awarded him honorary doctoral degrees. He is the author of five books, best-sellers in the scientific field. In 1941 he was elected president of the Institute of Radio Engineers (IRE). IRE awarded him its Medal of Honor in 1950.

J. F. H. Douglas (AM'20, F'38, Member for Life), associate professor of electrical engineering, Marquette University, Milwaukee, Wis., has been made professor emeritus, although he is not yet retiring. He has been a member of the electrical engineering faculty at Marquette for 35 years. He has served on AIEE's Electrophysics Committee (1926–28) and Technical Program Committee (1936–37).

A. W. Manby (AM'22, M'32), assistant general manager, administration, Hydro-Electric Power Commission of Ontario, Toronto, Ont., Canada, is now general manager in charge of over-all administration of commission affairs. **Otto Holden** (M'51), assistant general manager of engineering, Hydro-Electric Power Commission of Ontario, has been made chief engineer directly responsible to the commission for the completion of the Niagara and St. Lawrence power projects.

W. E. Sirvatka (AM '48), engineer, Jack and Heintz, Inc., Cleveland, Ohio, has been transferred to the Chicago, Ill., office. He will direct all Jack and Heintz commercial motor sales in the Chicago territory and will also serve as an application engineer assisting customers with the design and use of special motors for domestic, commercial, and industrial product lines. This move is the result of the steady growth of "customized motor" business at the company. Mr. Sirvatka joined Jack and Heintz 2 years ago as a motor application engineer with the Cleveland staff. Prior to that, he held design and sales positions with the Pioneer Service and Engineering Company in Chicago, the Glenn L. Martin Aircraft Company in Baltimore, Md., and the Bodine Electric Company in Chicago.

T. K. Greenlee (AM '47), chief electromechanical engineer of the Grand Rapids (Mich.) Division of Lear, Inc., has been appointed division engineering manager. In his new capacity as engineering manager, Mr. Greenlee will direct all phases of the division's engineering operation, supervising both its electromechanical and instrument-product engineering departments, and all its laboratories. He joined Lear in February 1953 as chief of the electromechanical engineering section. Prior to that, he was associated with the Barber-Colman Company as chief engineer in charge of actuator and controls development. He is a member of the Society of Automotive Engineers, the American Management Association, and the American Ordnance Association.

R. M. Kerchner (AM '25, M '33), professor, electrical engineering, Kansas State College of Agriculture and Applied Science, Manhattan, has been promoted to head the department of electrical engineering at Kansas State. He has been a member of the faculty for 33 years and has been professor of electrical engineering since 1934. He succeeds **R. G. Kloeffler** (AM '21, F '32), who has been head of the department since 1927. Mr. Kloeffler retired from administrative duties July 1. Professor Kerchner is a past chairman of the Kansas City Section of AIEE and a member of the national honorary organizations of Phi Kappa Phi, Tau Beta Pi, Sigma Tau, and Eta Kappa Nu. He served on AIEE's Membership Committee (1950–52).

Bernard Levine (AM '45, M '54), engineering director, Ketay Laboratories Division, Norden-Ketay Corporation, New York, N. Y., is now director of design and application engineering. He received his bachelor of science in electrical engineering from Cooper Union and his master of science in electrical engineering from New York University. He has been a member of the Advisory Committee on Synchros of the Department of Defense. Mr. Levine is responsible now for the design and application of products of both the Precision Components Division and the Instrument and Systems Division of the corporation. These products include servomechanism components, sensing and measuring instruments, aircraft instruments, computers, and automatic control systems.

N. J. Hoenie (AM '38, M '45), assistant chief engineer, Machine Division, Lincoln Electric Company, Cleveland, Ohio, has been appointed chief engineer of the division. He joined Lincoln Electric following his graduation from the Ohio State University with an electrical engineering degree in 1931. As a development engineer, he supervised many of the development projects for new welding machines which the company pioneered. He also supervised the development of Lincoln's line of transformer welders and the latest new type of welder, a universal model that gives both a-c and d-c welding current. Other types in which he pioneered were the air-cooled engine-driven welder and the diesel engine-driven welder. He is a member of the American Welding Society and the following honorary societies: Eta Kappa Nu, Tau Beta Pi, Sigma Xi.

N. W. Stunkard (AM '51), assistant chief engineer of Iron Fireman Manufacturing Company's Electronics Division, Portland, Oreg., has been named manager of Iron Fireman's Swenson Thermal Research, Inc., plant in Cleveland, Ohio. He joined the Iron Fireman Electronics Division in 1946 as a project engineer on motors and controls. Later he was made head of that division's experimental department, and not long afterward was named assistant chief engineer. Mr. Stunkard is a native of Oregon. He attended Willamette University in Salem, California Institute of Technology, and is a graduate of the University of New Mexico.

S. R. Gilford (AM '42), supervising electronic scientist, National Bureau of Standards, Washington, D.C., has been named director of the Medical Instrument Division of The Colson Corporation, Elyria, Ohio. The division recently was established to produce a line of electronic hospital instruments which include an automatic blood pressure recorder, and a device used in the measurement of the flow of blood from the heart. Mr. Gilford has been at the National Bureau of Standards since 1948. While there he received a Meritorious Civilian Service Award for his work on demolition devices, and the Department of Commerce Medal. A graduate of Massachusetts Institute of Technology, he also worked for the Bureau of Naval Ordnance on such underwater ordnance devices as mines and torpedoes. He has served on AIEE's Electrical Techniques in Medicine and Biology Committee (1952–55).

H. H. Warren (AM '46), assistant manager of the New York, N. Y., branch sales office of The Electric Storage Battery Company, has been appointed assistant sales manager of the company's Exide Industrial Division with headquarters in the general offices at Philadelphia, Pa. Associated with the company in New York since 1921, he started as a battery assembler and was promoted to production clerk in 1922. His first sales position began in 1925 when he was assigned to radio dealer battery sales. Then, beginning in 1927, he specialized for 6 years in sales of emergency lighting equipment. In 1933 Mr. Warren became automotive replacement field salesman to establish and develop wholesale distributors in New Jersey and southern New York areas. He held this position until November 1942 when he entered the U. S. Army. He served in the Persian Gulf Command and was attached to the Iranian State Railway supervising diesel locomotive maintenance. By 1945 he held the rank of major and had served as a battalion commander. He returned to The Electric Storage Battery Company in New York as industrial products salesman and became assistant manager of the branch in 1948.

OBITUARIES . . . .

Edwin Wilbur Seeger (AM '16, M '19, F '36, Member for Life), AIEE Director and vice-president in charge of development and assistant secretary, Cutler-Hammer, Inc., Milwaukee, Wis., died on August 29, 1955. Elected to the Board of Directors in 1953, his term was due to expire in 1957. Mr. Seeger was born in Bucyrus, Ohio, May 22, 1892. Following his graduation from Ohio State University in 1913, he joined Cutler-Hammer in the shop and engineering department, becoming general supervisor of the engineering department in 1922. He became assistant chief engineer in 1928, chief engineer in 1938, manager of development in 1939, and vice-president and assistant secretary in 1945. Mr. Seeger was a member of Eta Kappa Nu and Tau Beta Pi, the National Society of Professional Engineers, the Wisconsin Society of Professional Engineers, and the Engineers' Society of Detroit. He was active in Institute affairs, having served as vice-president, District 5 (1949–50), as chairman of the Milwaukee Section (1929–30), and also on the following AIEE committees: Automatic Stations (1927–29); Applications to Iron and Steel Production (1935–37); Executive (1953–54); Technical Operations (1953–54); and Code of Principles of Professional Conduct (1954–55). In addition, at the time of his death Mr. Seeger was a member of the AIEE Lamme Medal, Edison Medal, and General Applications Division Committees, and of the Committee on Registration of Engineers which he had served continuously, with the exception of 1951–52, since 1949.

MEMBERSHIP . . .

Applications for Election

Applications for admission or re-election to Institute membership in the grade of Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before October 25, 1955, or December 25, 1955, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

De Mel, C. H. J., Kandy Municipality, Kandy, Ceylon
Howard, J. C., Standard Oil Co. (Ind.), Whiting, Ind.
Kahn, L., Aerovox Corp., New Bedford, Mass.
Levin, J., Sandwell & Co., Inc., Seattle, Wash.
Rauch, S. E., University of California, Goleta, Calif.
Ridout, W. J., Jr., *The Farm Magazine*, New York, N. Y.
Williams, A. T., Weston Electrical Instrument Corp., Newark, N. J.

7 to grade of Member

OF CURRENT INTEREST

Aerial view of new G-E Metals and Ceramics Building shown in background near the water tower

New G-E Building Dedicated for Metals and Ceramics Research

A RESEARCH FACILITY destined to provide new materials for the future—for applications ranging from fast rockets and atomic power plants to labor-saving kitchen equipment—was dedicated late in August at the General Electric Research Laboratory, Schenectady, N. Y.

The dedication ceremonies for the new 5-million dollar Metals and Ceramics Building, described by the company as a complete processing laboratory, concluded a week-long program of conferences and seminars attended by some of the nation's leading scientists, professors of metallurgy and ceramics, and representatives of the company's operating departments to be served by the new laboratory facility. "The week's activities," according to Dr. C. G. Suits, General Electric Company vice-president and director of research, "were planned to demonstrate the growing significance of metallurgy and ceramics as sciences, to emphasize the importance of metallurgy and ceramics to the nation's industry and defense, and to bring attention to the vital role the new building would have in the General Electric Company's future." It was pointed out that completion of the Metals and Ceramics Building is part of the 13-million dollar expansion program for the Research Laboratory at The Knolls announced last year. At that time, General Electric Company president Ralph J. Cordiner reasserted his expectation that Schenectady will become "the industrial research center of the world."

Dr. J. Herbert Hollomon, manager of the Metallurgy and Ceramics Research Department, has stated that the objectives of the huge new laboratory building at The Knolls are:

1. To ascertain and analyze the areas of most critical need for materials and processes.
2. To develop new processes for new businesses.
3. To develop new materials to improve products.
4. To study existing materials and obtain a better understanding of their properties and processing.
5. To operate pilot plants and obtain economic data.

According to Dr. Hollomon, the constant growth of the company and the ever-increasing diversity of needs have necessitated the expansion of the facilities with which these objectives were accomplished in the past.

The new building, which measures 312 by 160 feet and has more than 75,000 square feet of floor space, seems more like a factory than a laboratory. Towering equipment, dra-

TEST SAMPLES for chemical analysis are taken from the one-ton arc-melting furnace installed in the new Metals and Ceramics Building at the General Electric Research Laboratory

A HEATED ROD is fed into the high-speed mill recently installed at the new Metals and Ceramics Building. This mill features a reversing rectifier drive controlled by a new magnetic amplifier system.

SCIENTISTS, laboratory assistants, and skilled tradesmen work side-by-side in conducting experiments with the one-ton arc-melting furnace at the new Metals and Ceramics Building.

matic spark-showers from the huge furnaces, and the color and motion inherent in the handling of white-hot and red-hot metals add to the effect. Since ideas for new materials and processes frequently come from the "pencil and paper" and "test tube" work done in the basic research areas of the laboratory, many of the things the company's operating personnel must know before they can take advantage of new materials and processes can be learned only by trying them on a scale approaching actual industrial conditions. Thus, a building where this can be done necessarily must be nearly factory-size.

However, there is an obvious difference between this facility and a factory. Here standard as well as special equipment is operated under laboratory conditions emphasizing measurement and control, with freedom from production schedules.

These pilot operations also must be of a transitory nature. Ideas do not come to the new building to stay; they are either forwarded for actual use or sent back to the basic research scientists for further investigation. Then the building must be readily adaptable to the next project. The new building, therefore, has an internal structure like an "erector set," permitting quick assembly and easy alteration as a process is developed and perfected. Thousands of bolting holes, aligned throughout the building, from floor to roof, provide the required versatility. Huge traveling cranes can lift structural members into place and move heavy apparatus into more convenient locations, all on surprisingly short notice. Power supplies and service facilities have been distributed on a "modular" arrangement to permit flexibility. Services available on a "turn-the-handle" basis include compressed air, high and low pressure steam, city gas, nitrogen, oxygen, standard hydrogen, dried hydrogen (−90 C dew point), rough vacuum, distilled water, cooling water, and hot and cold tap water.

Facilities for the study of ceramics have been placed side-by-side with those for metallurgy for two reasons: first is the tremendous importance of ceramic materials in the electrical industry, for insulators, lamps, radio and television equipment, and other applications; second is that metallurgy and ceramics are closely allied fields, since both metals and ceramics are crystalline solids, and the laws governing their behavior are identical. It is thus important to make information developed in one field available to those working in the other.

To maintain the maximum opportunity for scientific interchange, the ceramics facilities in the new building have been closely integrated with those of metallurgy. An extensive area for ceramics formulation, heat treatment, and testing adjoins a similar metal-treating area. An unoccupied area has been set aside in anticipation that still more facilities will be needed as metallurgists and ceramists pool their knowledge to obtain outstanding metal-ceramic composites.

Otis Engineers Demonstrate New Trav-O-lator and Elevoice

THE TRAV-O-LATOR, a new concept in human transportation adapting the tested principles of the escalator to overland travel by means of an endless series of moving, metal-treaded platforms, was introduced recently by Otis Elevator Company.

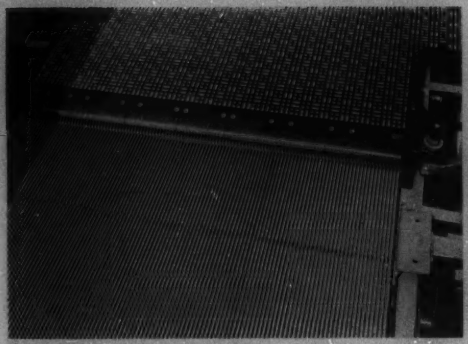
The new device provides a fast, safe, comfortable method of moving large numbers of persons horizontally or on an incline to higher or lower elevations in congested areas, such as airports, interconnecting subway, railroad and bus stations, shopping centers and sports arenas. LeRoy A. Petersen, president of Otis, pointed out that the new development is the result of extensive experimentation.

The platform is composed of a series of articulated, cleated treads, traveling on a wheel and track system, which affords a firm stable footing for passengers. The use of cleated treads, tested for more than half a century in many thousands of escalator installations, is a safety feature adopted for this device; it permits the use of a comb identical with that on a modern Otis Escalator to allow passengers to make easy transitions in getting on or off the moving treads. The articulated platform rides on ball bearing wheels.

Installations of unlimited length can be made in series, with gradients of as much as 14 degrees. While high speeds are theoretically possible, actual rates will be governed by the requirements of individual installations and human comfort. It was pointed out that actual passenger travel on a prototype model indicated that a speed of 180 feet a minute was practical.

The new device will be available in two widths. The 32-inch model will accommodate an adult and child side-by-side and

PROTOTYPE of the Otis Trav-O-Lator shown here has been stripped of balustrades and other normal exterior protective and decorative parts.



"COMBING" action at terminal of Otis Elevator Company's Trav-O-Lator enables passengers to make a safe, smooth transition in boarding and leaving. Cleated treads, permit the metal tread ribs to mesh with the combing device.

OPERATING mechanism of Otis Elevator Company's Trav-O-Lator shows handrail drive sheave and handrail tightener device (top); drive machine (lower left), and mechanism for return of cleated, metal-treaded platforms.

will carry up to 7,500 passengers an hour, while the 48-inch size will accommodate two adults side-by-side and carry up to 12,000 persons an hour.

Another new device, the Otis-Elevoice, by means of which each car in a bank of automatic elevators calls its own floor stops, warns passengers who are obstructing its movements, and makes other announcements appropriate to its own special needs, has been recently announced.

Loudspeakers in each elevator equipped with this device, an optional feature in Otis automatic elevator installations, connect with one or more master drums on which any number of messages can be recorded electronically. The drums, usually located in the machine room, "pipe" to each car at any time 24 hours a day the message required by its movements at that moment.

Electronic car operating buttons which enable passengers in automatic elevators to select their own floor stops with the flick of a finger also have been announced. As a button on the elevator's operating panel is touched, it registers the call instantly and glows to assure the passenger that the call has been registered.

Symposium Planned on Applied Solar Energy

Equipment illustrating recent developments in the field of solar engineering, including a 5-to-10-hp sun-driven engine, will be on public display in Phoenix, Ariz., October 29–November 13 at the Solar Engineering Exhibit planned in conjunction with the World Symposium on Applied Solar Energy.

The symposium, to be held in Phoenix November 1–5, will draw some 1,000 scientists and engineers from all over the world interested in the effort to harness energy from the sun's rays. Many of these conferees will also attend an earlier conference on solar energy, called "The Scientific Basis," to be given October 31 and November 1 at the University of Arizona, Tucson.

L. W. Douglas, board chairman of the Southern Arizona Bank and Trust Company, is general chairman of the symposium, sponsored jointly by the Association for Applied Solar Energy, Phoenix; Stanford Research Institute, Menlo Park, Calif.; and the University of Arizona. M. L. Kastens, Stanford Research Institute assistant director, is vice-chairman of the event.

An estimated 30,000 to 40,000 persons are expected to attend the Solar Engineering Exhibit where approximately 65 displays of equipment and other demonstrations will be set up in the sun at the Phoenix Civic Center to show various methods of converting the sun's energy to useful purposes. The work of numerous individuals and research groups will be shown at the exhibit including contributions from the Massachusetts Institute of Technology research program led by H. C. Hottel. Material has also been made available by the University of Wisconsin research group headed by F. Daniels.

Among the 35 working models at the exhibit will be the 5-to- 10-hp solar engine manufactured in Lecco, Italy, by the Somor Company. The device, one of several solar engines to be shown, involves a flat-plate collector that uses the sun's rays to evaporate sulphur dioxide which then operates a vapor engine. The gas is condensed by a water-cooled condenser and returned to the collector in a continuous cycle.

V. Olgyay, associate professor at Princeton University's School of Architecture, has arranged to display a model of a solar-heated house designed for construction in Phoenix. He has also contributed a pair of solar instruments, one a sun-energy calculator which computes the sun energy incident on a surface for any latitude and time. The other, called a "shade dial," is a hand-sized device that helps determine the angle of the sun in the sky for locations at any latitude and for any time of the day or year. Another sun-angle calculator will be shown by Libby-Owens-Ford Glass Company, Toledo, Ohio, in addition to their display of models of various farm buildings showing construction methods for improved winter heat absorption.

Among a group of miscellaneous and historical items, light-energized clocks from Patek Philippe, Geneva, Switzerland, will be shown. This firm has developed new clock designs using energy from photoelectric cells to wind the mechanism.

The various exhibits will be arranged under the following classifications: world distribution of sunlight and instruments for its measurement; sunlight collectors and absorbers; food cookers; house and water-heating methods; high-temperature furnaces; mechanical engines; agricultural aids; and miscellaneous and historical items.

W. T. Lucking, president of the Arizona Public Service Company, Phoenix, is chairman of the Solar Engineering Exhibit Committee. E. J. Burda of Stanford Research Institute has charge of assembling devices and materials for the show.

Boy Keeps 5-Day Vigil During Flood Emergency

A 14-year-old boy who operated an emergency radio station night and day became the hero of Carpentersville, N. J., a small riverside community which was devasted in August by the raging floodwaters of the Delaware River.

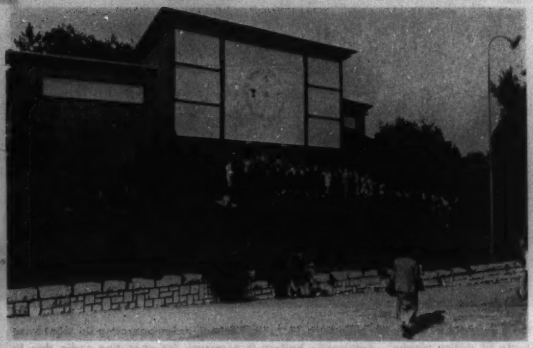
William Kober, who is a freshman at Phillipsburg, New Jersey, High School, took up his post at a mobile radio station in the heart of flood-ravaged Carpentersville and dispatched disaster control messages around the clock for 5 days. Carpentersville, located along the banks of the Delaware River in Pohatcong Township, was completely inundated by the flood. Fourteen houses were swept away and 22 others were severely damaged. Carpentersville was without communications.

Meanwhile, Robert Kearney of Arnolt Communications Services, Du Mont distributors, had been watching the progress of the flood in other areas. Realizing the value of communications in an emergency, Kearney and other Arnolt personnel began assembling Du Mont two-way radio equipment and offered their services to the Phillipsburg police, who advised them of the Carpentersville situation. Kearney reached the flood

(*Continued on page 952*)

International Conference of Peaceful Uses of Atomic Energy

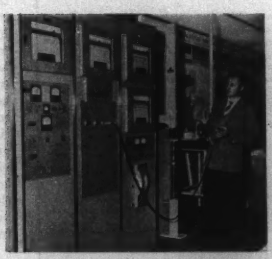
Geneva, Switzerland, August 8-20, 1955



A full-scale atomic reactor, a part of the United States Government's exhibit at the International Conference on Peaceful Uses of Atomic Energy, Geneva, Switzerland, was housed in this building.

The swimming-pool reactor from the United States was operated in complete safety with no complications to the audience.

Signing the documents which turned the U. S. reactor over to Switzerland for peaceful research work. Left to right: Walter Boveri, President of Swiss Reactor Corp.; Lewis L. Strauss, Chairman of U. S. A. E. C.; Miss Frances Willis, U. S. Ambassador to Switzerland; Paul Scherrer, Chairman of Swiss Commission of Nuclear Research; and W. F. Libby, Commissioner, A. E. C. of United States.



A visitor to the Palais des Nations in Geneva starts up a reactor and watches electronic units monitor the simulated explosive release of atomic energy.

▶Very high tension generator which produces at 1.4 million volts under 5 milliamperes feeds an accelerator tube with protons.

◀This cyclotron at the Centre de Physique Nucleaire de l'Université de Louvain furnishes 12.5 million electron volts. It was built at the Ateliers de Constructions Electriques de Charleroi, Belgium

Future Meetings of Other Societies

National Electronics Conference, Inc. October 3–5, 1955, Hotel Sherman, Chicago, Ill.

Society of Motion Picture and Television Engineers, 78th Convention. October 3–7, Lake Placid Club, Essex County, New York, N. Y.

Canadian Electrical Manufacturers Association, 11th Annual Meeting. October 5–7, 1955, Sheraton-Brock Hotel, Niagara Falls, Ont., Canada

Electrochemical Society, Inc. October 9–13, 1955, William Penn Hotel, Pittsburgh, Pa.

Systems and Procedures Association of America, Eighth Annual International Meeting. October 10–12, Sheraton-Cadillac Hotel, Detroit, Mich.

Eastern Electrical Wholesalers Association, Third National Electrical Industries Show. October 11–14, 1955, 69th Regiment Armory, New York, N. Y.

Audio Engineering Society Convention. October 12–15, Hotel New Yorker, New York, N. Y.

National Society of Professional Engineers, Fall Meeting. October 14–15, Peabody Hotel, Memphis, Tenn.

National Safety Council, 43d National Safety Congress and Exposition. October 17–21, 1955, Conrad Hilton, Congress, Morrison, and La Salle Hotels, Chicago, Ill.

American Welding Society, National Fall Meeting. October 17–21, 1955, Bellevue-Stratford Hotel, Philadelphia, Pa.

Atomic Industrial Forum and Carnegie Endowment for International Peace, International Atomic Energy Exhibit. October 20–November 3, 1955, United Nations Plaza, 46th St. and First Ave., New York, N. Y.

Institute of Management Sciences, Second Annual National Meeting. October 20–22, Park Sheraton Hotel, New York, N. Y.

Steel Founders' Society of America, Fall Meeting. October 24–25, 1955, The Greenbrier, White Sulphur Springs, W. Va.

American Standards Association, 37th Annual Meeting in conjunction with 6th National Conference on Standards sponsored jointly by ASA and the National Bureau of Standards. October 24–26, Sheraton-Park Hotel, Washington, D. C.

Pennsylvania Electric Association, Fall Meeting of Electrical Equipment Committee. October 27–28, 1955, Hotel New Yorker, N. Y. C.

National Conference on Industrial Hydraulics, 11th Annual Meeting, October 27–28, La Salle Hotel, Chicago, Ill.

Institute of Radio Engineers, East Coast Conference on Aeronautical and Navigational Electronics, October 31–November 1, Lord Baltimore Hotel, Baltimore, Md.

Association for Applied Solar Energy, the University of Arizona, and Stanford Research Institute, World Symposium on Applied Solar Energy. November 1–5, Westward Ho Hotel, Phoenix, Ariz.

The American Society of Mechanical Engineers, Diamond Jubilee Annual Meeting. November 13–18, Congress, Hilton, and Blackstone Hotels, Chicago, Ill.

National Electrical Manufacturers Association, Annual Meeting. November 14–18, Traymore Hotel, Atlantic City, N. J.

American Society of Refrigerating Engineers, Annual Meeting. December 1–3, Traymore Hotel, Atlantic City, N. J.

WILLIAM KOBER, 14 year old freshman at Phillipsburg, N. J., High School, shown operating Du Mont base station from tailgate of station wagon. Automobile battery is necessary for operating radio due to absence of commercial electric power in the area. William stayed on the job around the clock.

scene and set up a mobile radio on the tailgate of a chicken farmer's truck. It was at this point that young William Kober was pressed into service as a radio operator by his father, Gabriel Kober, Jr., who is director of Civilian Defense and Disaster Control in Pohatcong Township. The disaster control headquarters radio in Carpentersville later moved into what had been the front room of the Harty residence. Kearney rigged a temporary aerial to their television antenna and Billie Kober continued his vigil at the microphone, handling the grim communications attached to a catastrophe—the reports of parties searching for drowned bodies, requests for typhoid vaccine, and information concerning looters.

Now the message center is fairly quiet and Billie is getting much needed rest as Government and independent flood relief organizations carry on the work of restoring Carpentersville. But the great work—the man-sized job performed by Billie Kober—will not be soon forgotten in Pohatcong Township.

David Slayback, Region No. 1 director of New Jersey Civilian Defense praised the work of Billie and his father, and predicted that the services of industrial radio, typified by the sense of public duty shown by Arnolt Communications Services, may be counted upon to play a major role in civilian defense and disaster control.

Sweden Will Have Largest Subterranean Steam Power Plant

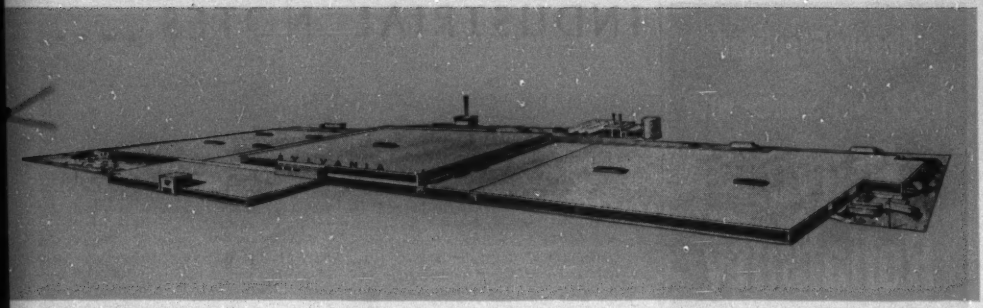
Blasting operations for what is claimed to be the world's biggest subterranean steam power plant commenced recently near Stenungsund, a small community not far from Gothenburg on the Swedish west coast. In October 1959, the first turbo-set will start operating in its atomic-bomb shelter, protected by a 300-foot roof of solid granite.

The new power plant, which is being built by the Swedish State Power Board, is designed for four steam turbo-generators, each with a capacity of no less than 150,000 kw. They will be the biggest so far built in Scandinavia. The first set was recently ordered from the Swedish turbine manufacturers STAL, of Finspong, which some time ago also delivered the large turbo-generator plant for the Power Board's stand-by steam power station at Västerås. The first STAL set for the new station is reported to cost $2,400,000.

The four sections of the Stenungsund plant, each consisting of a turbo-generator set and a boiler, will be housed in separate rock chambers, measuring 330 by 80 by 100 feet. The boilers will be fired with heavy oil which, together with the large size of the machines, makes it possible to automatize operations to a great extent. The oil will be unloaded directly from tankers into huge cisterns blasted into the rock, a pier capable of receiving tankers of up to 40,000 tons forming part of the building scheme. Including two km of subterranean conduits for cooling water for the turbines and certain other uses, over 35,000,000 cubic feet of rock will be removed, which will be used for road building and filling. The station will be equipped with a chimney with exhaust filter, extensive ventilation arrangements, water purifiers, etc. When fully completed, it will employ a staff of about 170.

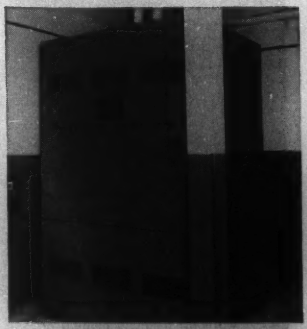
The Stenungsund steam power station is estimated to cost about $57,000,000. This is calculated to be only 10 per cent more than for a surface-ground plant of the same size, while maintenance costs will be lower.

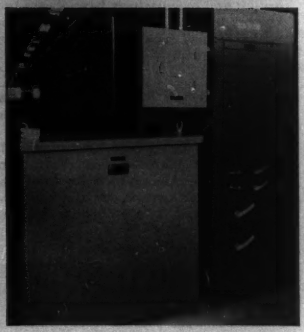
The State Power Board and the Swedish Allmanna Svenska Elektriska Aktiebologet (ASEA) are at present investigating the possibilities of designing an atomic power operated energy plant. At the opportune time it will also be possible to accommodate such a plant in the rock at Stenungsund, according to the power experts.



TRANSFORMERS throughout!

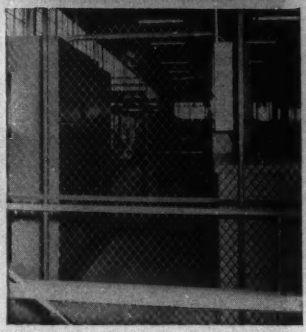
Shown here (left and right) are two of the four Uptegraff dry-type transformers used to provide both power and lighting current from the same distribution system, thus avoiding the duplication of units, common in the past. Two of the transformers are 750 KVA, and two are 300 KVA. All four are fed by 4160 volt circuits, and have 480Y/277 volt secondaries.





At the left is shown one of the Uptegraff dry-type transformers that provide 120-volt power. Two of these transformers are used, one being a 225 KVA unit, and the other 112½ KVA. Both have 480-volt primaries and 208Y/120 secondaries.

The photograph at the right shows how the dry-type Uptegraff transformers can be installed wherever desired, without vaults or other enclosures. This permits transformers to be safely located near the center of power usage, thus avoiding long costly runs of low-voltage circuits.



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Closely Regulated
D-C Power Source with
Proven
Reliability

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POWER
RECTIFIERS

Greatly simplified and stable circuitry with all-magnetic control. Fast response, no warm-up time, no hunting or drifting. Finest materials, encapsulated components. Lighter weight, smaller size, rugged. Mobile or stationary models of permanent dependability.

11 standard 28-volt models up to 1500 amps. Meets Spec. MIL-E-7894.

Write for interesting information on STAVOLT rectifiers.

McCOLPIN-CHRISTIE CORP.
3410 W. 67th Street, Los Angeles 43, California

INDUSTRIAL NOTES ....

Westinghouse News. The Westinghouse Electric Corporation has unveiled their new factory designed to produce parts for atomic power plants. The plant is located in Cheswick, Pa. Westinghouse has constructed, within this factory, a high pressure "proving ground" designed expressly for the full-scale testing of canned motor-pumps and valves used in nuclear power plants and atomic power systems.

The formation of an Industrial Heating Division has been announced. The new organizational unit will combine the functions of the company's induction heating activities, located at Baltimore, Md., and the industrial heating department, located at Meadville, Pa. Headquarters of the new division will be at Meadville, Pa. L. R. Hague has been named manager of the new division.

D. R. Tashjian has been appointed manager of engineering for the Electronics Division, Baltimore, Md. Mr. Tashjian, prior to his present promotion, was manager of the division's government engineering department.

General Electric Notes. Construction of a $400,000 factory building is planned at the General Electric Company's capacitor department Hudson Falls, N. Y. The new building will be used for fabrication and assembly of power capacitor racks and equipments.

Joseph W. Dreher has been appointed manager of engineering administration in the cathode-ray tube subdepartment at Syracuse, N. Y. Mr. Dreher had been employed in employee relations at Syracuse since September 1946, where he was concerned with the procurement of technical personnel.

General Electric will construct a multimillion dollar apparatus service shop in North Bergen, N. J., which will provide electrical maintenance facilities for New York State and New Jersey. The service shop is the 46th unit operated by the department, which is a component of the Apparatus Sales Division. It will be located on Tonnelle Avenue, Route 1, North Bergen, and will be serviced by the West Shore Division of the New York Central Railroad.

The appointment of Channing Dichter as manager of industrial and military product engineering in the cathode-ray tube subdepartment has been announced. Mr. Dichter will be responsible for development, design, and production of industrial and military cathode-ray tubes.

Appointment of Howard W. Bennett of Schenectady, N. Y., as consultant—marketing gear-motor planning study has been announced. Mr. Bennett will be responsible for all marketing phases. His office for the study will be in Fort Wayne, Ind.

The appointment of Charles P. Page as manufacturing engineering specialist for the distribution assemblies department has been announced. He will be responsible for formulating and recommending new and revised manufacturing methods and processes involving the development of plant layout and material handling methods, and the recommendation of sources of supply for tools, dies, and other facilities.

Bertram W. Mahoney of Schenectady, N. Y., has been appointed general manager of the company's industry control department. He succeeds C. A. Salmonsen who will be assigned to special projects in other departments of the company.

General Manufacturing Manager Named. The naming of Robert E. Kessler as general manufacturing manager for the Technical Products Division of Allen B. Du Mont Laboratories, Inc., has been announced. The Technical Products Division of Du Mont consolidates the manufacturing and sale of the company's technical products formerly produced by the Instrument Division and Communication Products Division. As general manufacturing manager Mr. Kessler will supervise the engineering department, the production control department, purchasing, manufacturing, and inspection.

Sangamo Electric to Build in South Carolina. The Sangamo Electric Company of Springfield, Ill. is planning to build a new manufacturing plant in Pickens, S. C. The plant will be operated by the Pickens Electric Manufacturing Company, a division of Sangamo Electric. The factory will manufacture electronic devices that are presently being manufactured at the company's plant in Marion, Ill.

Electrical Facilities Changes Name. Electrical Facilities Inc., of Oakland, Calif., has changed its name to Knopp Inc. While the company has been known as Electrical Facilities Inc., the transformers, and the testing and measuring devices which it designs and manufactures have always been known by the brand-name of Knopp. Under the new company name, the firm will continue to make the same products.

Sperry Electronic Tube Division Expands. Expansion of research and development work requiring additional engineering staff is planned by the Sperry Electronic Tube Division at Gainesville, Fla. Engineering activity will be directed toward research and development on klystron and traveling wave tubes, backward wave oscillators, and magnetrons.

Giannini Datex Division Moves. Giannini Datex Division has moved into a new building, located at 1307 South Myrtle Avenue, Monrovia, Calif. All sections—sales, engineering, and production, are located in the new facility. The Giannini Datex Division manufactures digital data recording equipment.

(*Continued on page 22A*)

THE ADVANTAGES OF

ROUND TUBE

BUS CONDUCTORS

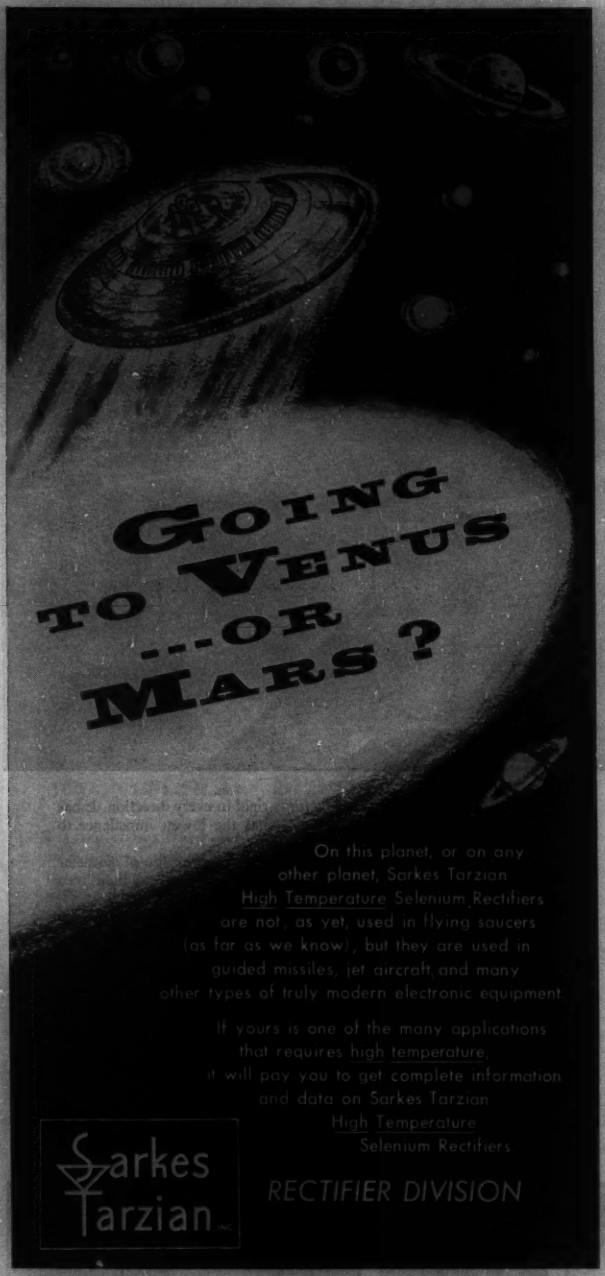
The tubular form of bus conductor is rigid in every direction. It has strength as a structural member. It has the lowest impedance to the flow of alternating currents.

Skin effect is at a minimum in tubes with a high ratio of diameter to wall thickness. At high voltages corona discharge is less than from conductors with edges or sharp corners.

Many engineers prefer pipe sizes standard, extra strong and double extra strong or "Type B" or the "Water Tube" schedules. Other engineers prefer tailor-made combinations of diameter and wall thickness best suited to the specific duty of each installation.

There is a complete line of ANACONDA Copper Bus Conductor designs for every type of installation and power requirement. Write for "ANACONDA Copper Bus Conductors" containing illustrations and detailed technical information. *The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.* 53129 Rev.

carry the load with ANACONDA® Bus Conductors


GOING TO VENUS ...OR MARS?
On this planet, or on any other planet, Sarkes Tarzian High Temperature Selenium Rectifiers are not, as yet, used in flying saucers (as far as we know), but they are used in guided missiles, jet aircraft and many other types of truly modern electronic equipment.
If yours is one of the many applications that requires high temperature, it will pay you to get complete information and data on Sarkes Tarzian High Temperature Selenium Rectifiers.
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Industrial Notes

(*Continued from page 18A*)

Allis-Chalmers Changes. F. J. Geiger has been named general manager of Allis-Chalmers Norwood (Ohio) Works. Mr. Geiger, manager of sales and engineering, electrical section, Norwood Works since 1944, succeed P. F. Bauer, recently named general manager of the company's Industrial Equipment Division.

Announcement has been made of the retirement of Didier Journeaux, patent attorney-in-charge, general machinery section, after nearly 30 years with the firm.

Nuclear Power Plant. Commonwealth Edison Company has signed a contract with General Electric Company for the construction of a nuclear power plant to be built entirely with private funds at a cost of $45,000,000. The contract calls for the building of the 180,000-kw boiling reactor plant. The plant will be built on the Illinois waterway, 47 miles southwest of Chicago, Ill. Its output will feed into the Commonwealth Edison system serving Chicago and northern Illinois. The plant, to be owned and operated by Commonwealth, is cosponsored by eight companies which are sharing in the developmental expense of the project.

The eight sponsoring companies have formally incorporated to carry out the research and developmental part of the construction. The new corporation, which is called Nuclear Power Group, Inc., succeeds an informal organization of a similar name which the participating companies have maintained for the last 2 years. Directors, representing the sponsoring companies, are: Philip Sporn, American Gas and Electric; S. D. Bechtel, Bechtel Corporation; T. A. Schlink, Central Illinois Light Company; Willis Gale, Commonwealth Edison Company; Allen Van Wyck, Illinois Power Company; H. B. Munsell, Kansas City Power and Light Company; J. B. Black, Pacific Gas and Electric Company; and J. W. McAfee, Union Electric Company of Missouri.

Square D Expands. Square D Company plans construction on a new plant to be located in Royal Oak, Mich., and has begun production at two recently completed units in Cedar Rapids, Iowa, and Secaucus, N. J. Square D will have 12 plants at the end of the year—10 in the United States, and the others in Toronto, Canada, and Mexico City, Mexico.

IRC to Open Fifth Branch Plant. International Resistance Company (IRC), has acquired a new branch plant located in Burlington, Iowa. Increased demand for the products to be manufactured in this plant, deposited and boron carbon type resistors, have necessitated the expansion of production facilities from the Philadelphia, Pa., plant to Burlington, Iowa. This will be IRC's fifth branch plant, in addition to its seven wholly owned subsidiary companies and five overseas licensees.

Bendix to Build New Research Lab. A million-dollar facility will be constructed in

(*Continued on page 26A*)

HIGHER INTERRUPTING RATINGS! SAME LOW COST!

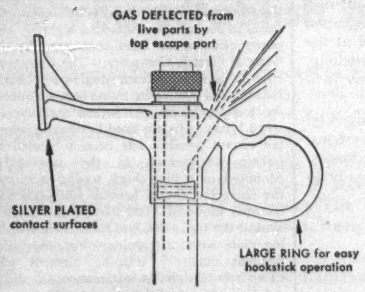
SOUTHERN STATES NEW TYPE CV-33-F CUTOUT

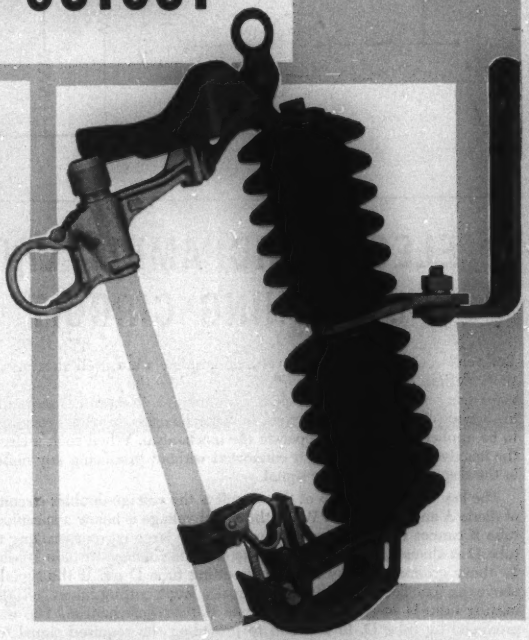
Here is Southern States' answer to stepped up protection for continually increasing system capacities—the new Type CV-33-F control-vented cutout . . . tougher, more versatile than any of its famous predecessors . . . at no increase in price!

Install the Type CV-33-F today with full assurance that it will take in stride the heavier faults sure to come in the years ahead. Build a new margin of safety into your system which will mean substantial savings over the years!

The Type CV-33-F functions dependably in all ranges of cutout operation . . . from restricted faults to those of high magnitude. It is a simple, sturdy unit. Nothing to go wrong or get misplaced. No spare parts necessary to put it back into operation—only a conventional universal button-head link.

Specify Southern States Type CV-33-F Cutouts and get extra protection without extra cost.


GAS DEFLECTED from live parts by top escape port
SILVER PLATED contact surfaces
LARGE RING for easy hookstick operation



Check These Interrupting Ratings Available at No Increase in Price

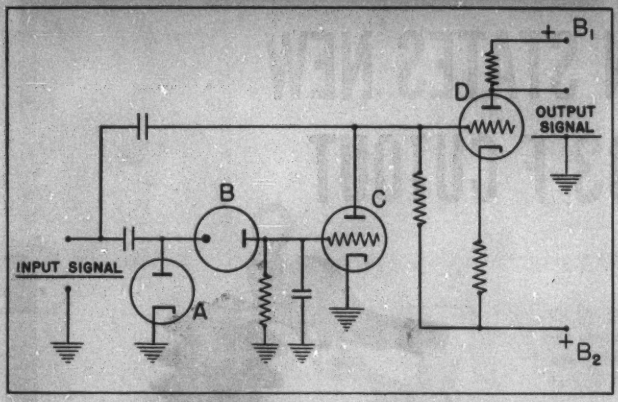
TYPE CV-33-F			TYPE CV-33-FH		
KV	CONT. CURRENT	RMS AMPS INT. CAPACITY	KV	CONT. CURRENT	RMS AMPS INT. CAPACITY
5	100	6,000	5	100	8,000
			5	200	8,000
7.5	100	6,000	7.5	100	8,000
			7.5	200	8,000
15	100	4,000	15	100	6,000
25	100	2,000	15	200	6,000

NOTE. ALL STATIONARY CONTACTS ARE RATED 200 AMPS

SOUTHERN STATES EQUIPMENT CORP.
HAMPTON, GEORGIA

IN CANADA: Dominion Cutout Co., Ltd., Toronto

SINCE 1915 LEADERS IN AUTOMATIC CONTROL



ELECTRONIC AMPLIFYING SWITCHING CIRCUIT

Both electronic switches and electronic amplifiers are used successfully in computer design. A very unusual circuit, patented by the Ford Instrument Company, combines positive switching action with amplification, and is particularly useful in such applications as multi-speed servomechanisms, in which several signals are to be applied selectively to operate the mechanism. When such a circuit is used, the inactive signals can be left connected without producing any noise whatever in the response to the active signal.

The key to the operation of this circuit is the voltage-doubler circuit consisting of diode A and gas tube B. When the signal voltage is below a specified level, gas tube B cannot fire and triode C draws a very large current, making the grid of tube D at almost ground potential. The cathode voltage of triode D is at a voltage B_2 above ground, thereby effectively cutting tube D off. If the signal voltage is above the specified level, gas tube B breaks down, cutting tube C off, thereby permitting tube D to conduct and actuate the servomechanism. The amplification produced by tube D, in addition to providing the required signal level at the servomechanism, contributes also to the effectiveness of the electronic switching, and the resultant circuit is more compact and has a higher parts economy than produced by the use of a separate switch and amplifier.

Electronic circuitry is but one of the many facets of Ford Instrument design and development. Ford Instrument engineers work every day with control systems, using mechanics, electronics, hydraulics, electro-mechanics, magnetics, and atomics. If you have a problem in automatic control, Ford Instrument stands ready to help you.

Visit our Booth #4 at MAN, THE ATOM AND THE FUTURE — Oct. 19-Nov. 3—Carnegie International Center, New York, N. Y.

75

FORD INSTRUMENT COMPANY
DIVISION OF SPERRY RAND CORPORATION
31-10 Thomson Avenue, Long Island City 1, N. Y.

ENGINEERS
of unusual abilities can find a future at FORD INSTRUMENT COMPANY. Write for information.

Industrial Notes

(*Continued from page 22A*)

the Detroit, Mich., area by the Bendix Aviation Corporation for its Research Laboratories Division. The building will be located on a 46-acre site, on the northwest outskirts of the city, and will be ready for occupancy next year. The division was formed in 1942 as a central research laboratory to serve all divisions of the corporation, and to maintain basic research in industrial science.

General Dynamics News. A broad expansion of the West Coast activities of the Stromberg-Carlson Division of General Dynamics Corporation has been announced. In San Diego, Calif., Stromberg-Carlson will take over from the corporation's Convair Division the production of the charactron tube. In Los Angeles, Stromberg-Carlson has acquired the former Electronic Control Systems, Inc., which specializes in automation, electronic computers, and data handling systems. Stromberg was previously a part owner.

A separate department to direct research and development work on atomic-powered aircraft has been created at General Dynamics Corporation's Convair Division plant. The nuclear research and development department will report to Mr. Esenwein on matters of policy, programing, and sales; and to Frank W. Davis, chief engineer at Convair-Fort Worth, on technical, organizational, and financial matters.

NEW PRODUCTS . .

High-Shock Navy Circuit Breaker. A single-pole high-shock circuit breaker, designed to meet the United States Navy specifications for use in shipboard lighting and power circuits, has been announced by the General Electric Company. The Navy type *ALB-7*, is a high-shock single-pole circuit breaker in a 50-ampere frame size. To meet shock requirements, such as those encountered when heavy guns are fired in naval combat, the circuit breaker has been subjected to jarring punishment in the laboratory. Mounted in a high-shock testing machine, the energized circuit breaker has withstood hammer blows of 2,000 foot-pounds impact against the top, sides, and back of its mounting plate without tripping. Yet, the independent magnetic tripping element will cause it to trip almost instantaneously under short-circuit conditions, and a thermal tripping element will open the circuit breaker when a dangerous overload occurs.

Visual Tachometer. Boulin Instrument Corporation has announced a new lightweight visual tachometer called Visutac, which measures rotary or vibratory speeds of

(*Continued on page 30A*)

FACT:

Versatility, economy of Type A recorders help you establish greater system efficiencies

Dependable Westinghouse Type A recorders have gained wide acceptance by utilities for making load surveys. Industry has found them ideal for checking machine operation and factory distribution systems.

FACT: Low Cost—your recording costs are low with the Type A because it is simplified, easy to service . . . maintenance costs are kept to a minimum. The Type A is also low in initial cost . . . you can use it freely whenever, wherever you wish.

FACT: Dependable—high-torque mechanisms give you maximum operating stability under the most severe conditions. Pen friction is decreased, energy consumption is low, precise leveling is unnecessary.

FACT: Versatile—Westinghouse Type A recorders are available in five types to meet your every need for low-cost recording of a-c and d-c voltage and current: portable, switchboard flush, switchboard projection, wall mounting, socket mounting.

You can be sure of accurate recordings or indications of electrical values, whatever the application, when you specify Westinghouse instruments.

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FOR MORE FACTS: Call *The Man With The Facts* . . . your Westinghouse sales engineer. Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-40465

YOU CAN BE SURE... IF IT'S

Westinghouse

FROM NORTH POLE...

Note to ad manager:
← Picture isn't appropriate!
Don't you know it's just as
cold at the South Pole as
it is at the North Pole?
H.A.C

NOTE TO BOSS! Sure!
but who wants to cook
at Eskimos all the time?
H.P.B

TO SOUTH POLE...

IT'S

STACKPOLE

BETTER BRUSHES...for all rotating electrical equipment . . . automotive, aviation, traction and industrial.

DEPENDABLE CONTACTS...Carbon, graphite, metal powder and precious metal types specifically "tailored" to your equipment and operating conditions.

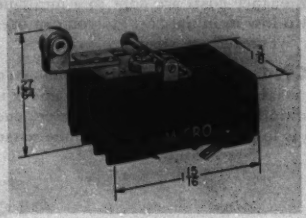
...And dozens of carbon, graphite and metal powder specialties.

STACKPOLE CARBON COMPANY, *St. Marys, Pa.*

(Continued from page 26A)

machinery or objects from a distance of 3 to 50 feet, and more. The device operates by a spring-wound mechanism which stops motion, by a stroboscopic principle. Its applications include accurate measurement of the speed of rotating objects having no accessible shaft ends such as drills, mixers, and governors. It is also used for objects such as fans, blowers, pumps, propellers, and turbines. By use of this visual tachometer, it is possible to determine the optimum safe speed of rotating and vibratory equipment for efficient performance. For full details write to: Boulin Instrument Corporation, 65 Madison Avenue, New York, N. Y.

Single-Actuated Dual Switch. A single-actuated dual switch has been developed by Micro Switch of Freeport, Ill., a Division of Minneapolis-Honeywell Regulator Company. This low-force, double-pole switch that can switch two isolated circuits at the same time, is designated the *6AS13*. It consists of two basic switching units operated by a single roller-lever actuator. Operating point of one switching unit is field adjustable to provide either simultaneous actuation or a definite sequence of operation. The *6AS13* is available with a variety of lever lengths. Basic switching units of the *6AS13* are listed at 15 amperes—125, 250 or 460 volts a-c; 1/2 ampere—125 volts d-c; and 1/4 ampere—250 volts d-c. Various other switching units can be used to provide higher electric capacity for d-c circuitry. Operat-

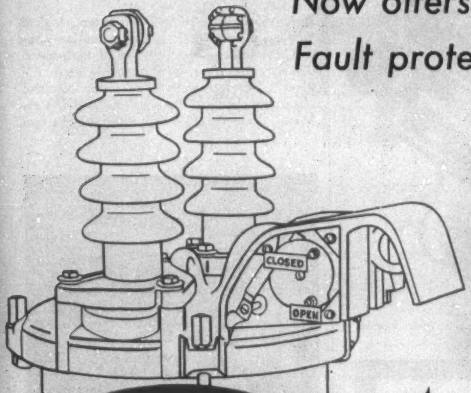


(Continued on page 32A)

R&IE

Type MB-2 ..the All New AUTOMATIC CIRCUIT RECLOSER

Now offers much greater Temporary Fault protection - 3 exclusive ways —



1 **FASTEST INTERRUPTION** of any Recloser—1 cycle

2 **FASTEST RESTORATION** of any Recloser—20 cycles

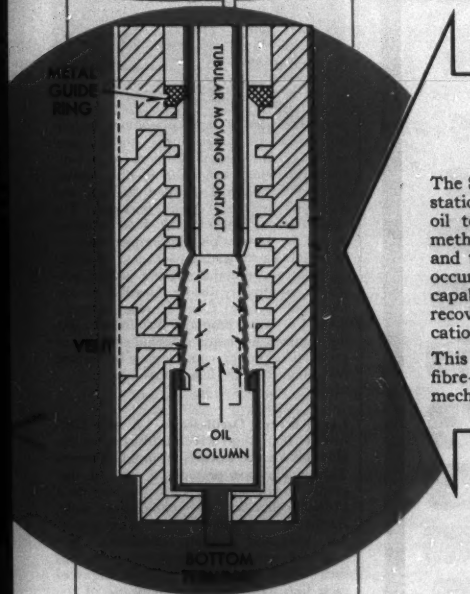
3 **NEW INTERRUPTION PRINCIPLE**—the

SC-OC

SINGLE CONTACT—OIL COLUMN

The Single, Tubular Contact, during operation, moves off the stationary Column of Oil, progressively exposing cool, clean oil to the area where arcing occurs. This arc-quenching method, in conjunction with the interrupting pressure chamber and the radial vents, is so highly effective that interruption occurs in the first half-cycle. Tests prove that it is more than capable of handling both high and low fault currents, and the recovery voltages encountered in any of its intended applications.

This new interrupting principle requires no fibre-to-metal or fibre-to-fibre assemblies—thus eliminating any possibility of mechanical interference resulting from moisture-swollen fibre.



INTERRUPTER CHAMBER SECTIONAL VIEW

Showing tubular moving contact at half way point in operating travel—arc is at highest intensity, about to separate.

Interrupting Capacities

Continuous Current Rating—Amperes	Amperes, RMS Symmetrical at System Voltages of— 4.8 Kv.	7.2 & 14.4 Kv.
100	6000	4000
140	6000	4000
200	6000	4000
280	6000	4000

Write for Bulletin No. 1550B

●

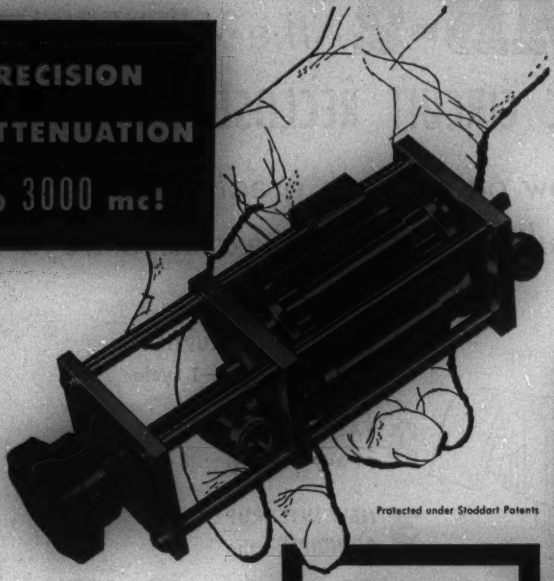
R&IE EQUIPMENT DIVISION

I-T-E Circuit Breaker Co.

GREENSBURG, PENNA.

INDOOR BUS SUPPORTS and BUS FABRICATION • OUTDOOR BUS SUPPORTS and AIR SWITCHES • SUBSTATION

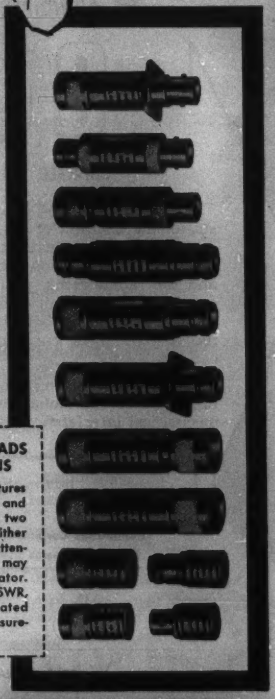
PRECISION ATTENUATION to 3000 mc!



Protected under Stoddart Patents

six-position
TURRET ATTENUATOR
featuring PULL-TURN-PUSH *action*

FREQUENCY RANGE: dc to 3000 mc.
CHARACTERISTIC IMPEDANCE: 50 ohms.
CONNECTORS: Type "N" Coaxial female fittings each end.
AVAILABLE ATTENUATION: Any value from 1 db to 60 db.
VSWR: 1.2 max., dc to 3000 mc/s, values from 10 to 60 db. As value decreases below 10 db, VSWR increases to not over 1.5.
ACCURACY: ± 0.5 db.
POWER RATING: One watt sine wave power dissipation.



SINGLE "IN-THE-LINE" ATTENUATOR PADS and 50 ohm COAXIAL TERMINATIONS

This new group of pads and terminations features the popular Type C and Type N connectors, and permits any conceivable combination of the two styles. For example, the two connector types, either male or female, can be mounted on the same attenuator pad, with or without flanges, so that it may serve as an adapter as well as an attenuator. Frequency range, impedance, attenuation, VSWR, accuracy and power rating are as designated above. Send for free bulletin entitled "Measurement of RF Attenuation."

STODDART AIRCRAFT RADIO Co., Inc.
6644 B Santa Monica Blvd., Hollywood 38, California • Hollywood 4-9294

New Products

(*Continued from page 30A*)

ing characteristics of the switch, assembled with two 15-ampere basic switch units, are: operating force, 8 ounces maximum; release force, 1/2 ounce minimum; differential travel, 0.109 inch maximum; and overtravel, 0.020 inch minimum.

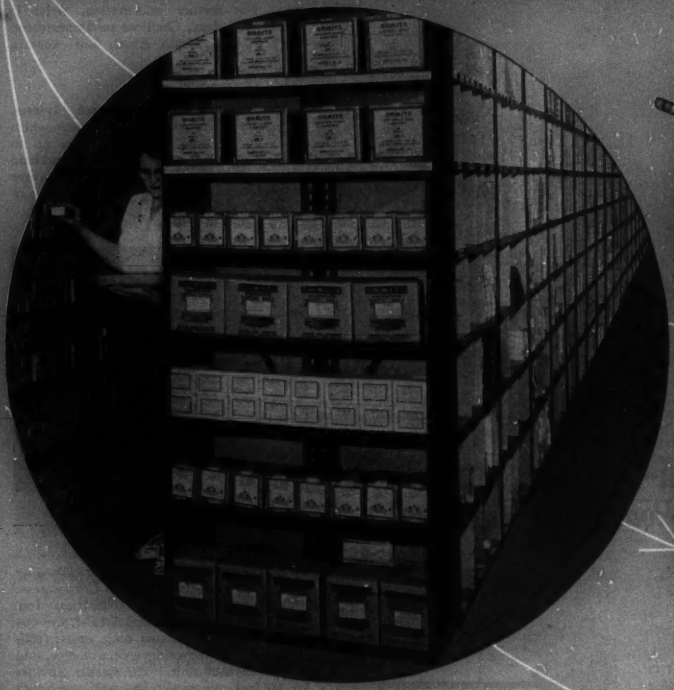
Pulse Circuits. Digital computers, logical analyzers, simulators, and automation control systems can be built up of high-speed digital computing components called *3C*-Blocs. Developed by Computer Control Company, Inc., 92 Broad Street, Wellesley, Mass., these computer building-blocks can

perform nearly all digital operations, including arithmetic computation, storage, programing, and logical decision, at a 1-mc pulse repetition rate. The *3C*-Bloc consists of 15 gating packages, called *3C*-Pacs, and one synchronizing "clock" package. The operations performed by a *3C*-Bloc are determined by simple plug-in jumper connections, joining the gating packages. A single *3C*-Bloc can be a shift register, adder, subtracter, multiplier, divider, function generator, code converter, or storage memory. Special purpose computers for aircraft landing systems, automatic machine controls, or production process controls can be formed with 30 or more *3C*-Bloc components.

Large Screen Oscilloscope. A new Electromec, Inc., large screen multichannel display oscilloscope features 40 input channels. This oscilloscope provides a vertical line graph 9-inches high by 12-inches wide on a 17-inch cylindrical face cathode-ray tube. Each vertical line terminates in a dot to permit rapid and accurate readability. The output of each of the 40 amplifiers is scanned each 1/4 second. The vertical length of each line indicates the peak value of the maximum a-c input voltage which existed during the previous 1/4 second. A calibrated graticule is provided in front of the cathode-ray tube for easy reading of voltage values and channel identification. The frequency response of each channel is within 2 per cent from 10 cycles per second to 10 kc, and down no more than 3 db at 50 kc. Each channel input is high impedance,

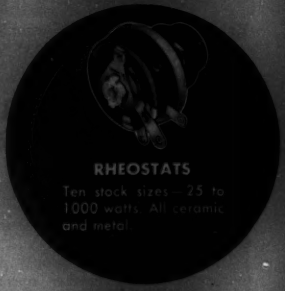
(*Continued on page 38A*)

WORLD'S LARGEST STOCK



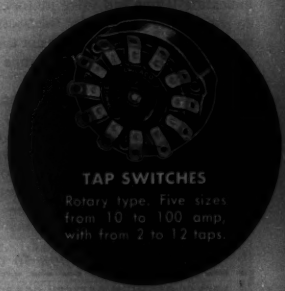
RESISTORS

Fixed and Dividohm adjustable wire wound types, 10 to 200 watts. Also composition type.



RHEOSTATS

Ten stock sizes—25 to 1000 watts. All ceramic and metal.



TAP SWITCHES

Rotary type. Five sizes from 10 to 100 amp. with from 2 to 12 taps.

What resistance components do you need in a hurry? From a factory stock of several million resistors, rheostats, and tap switches . . . in 1,859 types, sizes, and values . . . Ohmite can make fast delivery in reasonable quantities to meet your immediate requirements.

Furthermore, by tailoring your specifications to these stock items, you can always get speedy delivery that will help you keep experimental and pilot production operations on a smooth-running schedule.

To assist engineers and purchasing agents in making their selection from this huge stock, Ohmite *Stock Catalog* No. 24 contains complete, up-to-date information on all Ohmite stock items. Resistance values, ratings, specifications, and other helpful information are included.

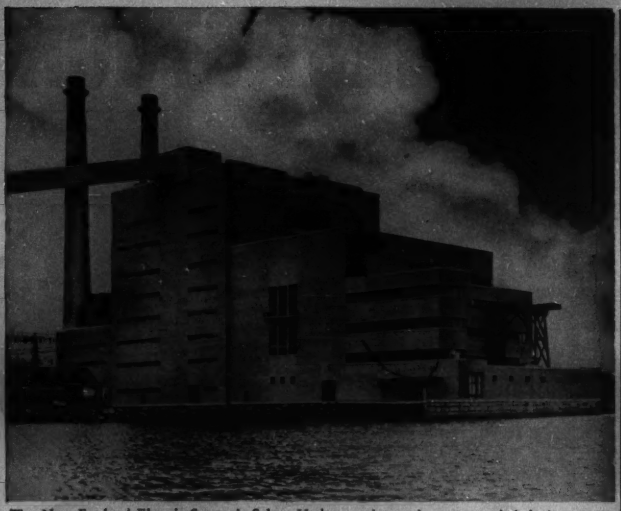
NEED RELAYS? Ohmite Amrecon Relays are available in 61 stock types. Write for Bulletin R-26.

SEND FOR STOCK CATALOG NO. 24

OHMITE®

MANUFACTURING CO.

3614 Howard St., Skokie, Ill. (Suburb of Chicago)



The New England Electric System's Salem Harbor station assigns seven vital duties to one storage battery . . . needs one that will perform faithfully with little supervision.

7 day-and-night duties
...call for Nicad on the job

When you say, "made for the job", you're describing the NICAD battery in this power plant installation.

The NICAD is the normal power source for circuit breaker operation, indicating lamps and valve motors. It is an emergency source for vibrators for clock recorders, motors for main turbine seal oil and bearing oil pumps and station lighting.

This battery was chosen because it is rugged structurally, chemically and electrically. Its dependability is worth more — but it actually is lowest in over-all costs. It is being picked for many of the *vital services* for which its counterpart, the nickel cadmium battery, has been long and successfully used in Europe. It is something you'll want to know more about. Data available.

The Battery with the Steel Constitution

Use coupon to obtain Nicad information

NICKEL CADMIUM BATTERY CORPORATION
Box 511, Easthampton, Mass.

Please send further data on the NICAD battery. Our special fields of interest are (please check)

☐ Switchgear Operation ☐ Emergency Light and Power ☐ Telephone Service ☐ Stationary Engine Starting ☐ Communications ☐ Signal Operation ☐ Laboratory ☐ Marine Standby

Name.....

Function.....

Company.....

No. and St.....

City.....Zone.....State.....

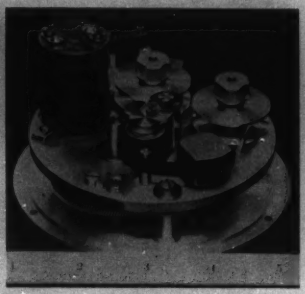
40102

New Products

(*Continued from page 32A*)

single-ended with one side grounded. The maximum sensitivity for each channel is 45 millivolts peak for full 9-inch vertical deflection. For further information, write to Electromec, Inc., Oscilloscope Department, 5121 San Fernando Road, Los Angeles, Calif.

Tape-Recording Accelerometer System. A tape-recording accelerometer system which can reliably measure accelerations up to ±60 g in guided missiles, air, sea, and land vehicles, underwater devices, and ordnance equipment without the use of direct cable or



wireless connections, has been developed by the Gulton Manufacturing Corporation, associated with Gulton Industries, Inc. Designated Glennite model *KAT-1*, the system is comprised of two basic units: self-contained, self-recording accelerometer, and a tape playback unit. The system provides for an instantaneous 30-second permanent tape recording of vibration and shock accelerations in moving devices. For further information write to Lawrence Oakley, Gulton Manufacturing Corporation, Metuchen, N. J.

MechaKit. The new MechaKit, by Servomechanisms, Inc., is now available for use in the laboratory for electromechanical development, and control simulation. These kits consist of an assortment of mechanical development apparatus which has been selected by careful analysis. The plastic case can be used as a tote box for transporting the MechaKit from one laboratory position to another. When not in use, the precision parts can be stored in the piece-marked wells in the removable plastic inserts. Available in three sizes, they are designed for engineering, industrial, and university laboratories. For detailed information, write to Servomechanisms, Inc., Components Division, 625 Main Street, Westbury, N. Y.

Subminiature I-F Amplifier. A new series of subminiature i-f amplifiers used in airborne radar systems and broadband receivers has been developed and produced by Maxson Instruments, a Division of The W. L. Maxson

(*Continued on page 40A*)

now selenium rectifiers

designed for printed circuits

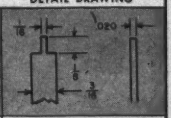
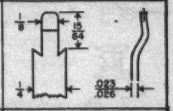
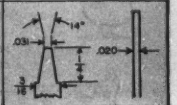
Four output ratings from 65 to 150 milliamps, and a choice of three terminal styles, are now available from Federal to meet your printed circuit requirements.

The new terminal designs cut your assembly and soldering costs . . . permit rapid *automatic* or *manual* insertion into printed circuit boards.

Terminal shoulder stops keep the rectifier plates off the board. Result: rectifier cooling is improved and extra board area is freed for additional printing!

And, as with all Federal selenium rectifiers, *you can count on* their long life, high output voltage, low temperature rise, excellent humidity resistance, and UL acceptance.

TERMINAL TYPES

TYPE	DESCRIPTION	DETAIL DRAWING
a	**Square Tipped**—for light-gauge printed circuit boards up to 1/16" thick.	
b	**Snap-In**—for 1/16" printed circuit boards subject to vibration or inversion. Terminals lock rectifier in place.	
c	**Tapered**—for maximum ease of insertion in heavy-gauge printed circuit boards up to ⅛" thick.	

FEDERAL PRINTED CIRCUIT RECTIFIERS												
FTR No.	1266	1279	1265	1308	1444	1357	1297	1445	1400	1383	1494	1495
DC Output ma (maximum)	65	65	65	65	65	75	75	75	100	100	100	150
AC Input V (rms maximum)	130	130	130	130	130	130	130	130	130	130	130	130
Terminal Type	A	B	A	B	C	A	B	C	A	B	B	B

Federal

A DIVISION OF IT&T

For more information on Federal Printed Circuit Rectifiers phone NUtley 2-3600, or write Dept. F-915.

Federal printed circuit rectifiers can be designed for your application in ratings up to 195 volts AC and 600 milliamps DC

Federal Telephone and Radio Company

A Division of INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

COMPONENTS DIVISION • 100 KINGSLAND ROAD • CLIFTON, N. J.

In Canada: Standard Telephones and Cables Mfg. Co. (Canada) Ltd., Montreal, P. Q.

Export Distributors: International Standard Electric Corp., 67 Broad St., New York

Wet... but not worried!

Stoddart NM-10A Radio Interference and Field Intensity Meter*
covering the frequency range of 14 kc to 250 kc

CHANCES ARE YOU'LL NEVER SUBJECT YOUR NM-10A TO THIS KIND OF TREATMENT..

BUT IT'S NICE TO KNOW THAT IT CAN TAKE IT IF IT HAS TO! We turned the hose on the AN/URM-6B — the Navy equivalent of the Stoddart NM-10A — in accordance with Navy specifications. Immediately afterward it was disassembled and found to be dry as a bone inside. And much to our satisfaction, the Navy inspector smiled!

Whether you use this fine, rugged instrument for field intensity measurements of carrier current systems, Navy, maritime or other services . . . or for surveys of conducted or radiated interference, you'll find that the ***NM-10A CAN TAKE IT*** . . . whether in the lab or in the field.

A complete selection of accessories is available, expanding the utility of the NM-10A to make it one of the most versatile instruments you have ever used.

Write today for further information. Learn about the excellent sensitivity . . . the "hand calibrated" accuracy . . . the sturdy, dripproof construction, enabling use in driving rain or snow . . . the A. C. power supply that permits operation from 105 to 125 volts or 210 to 250 volts A. C., 50 to 1600 cps.

The NM-10A is the identical instrument we supply to the Navy as the AN/URM-6B, a Class One instrument, as shown in MIL-I-16910 (SHIPS). It was designed and is manufactured exclusively by Stoddart Aircraft Radio Co., Inc. When you buy the NM-10A you're getting a quality instrument that meets the rugged requirements of the U. S. Navy!

*** Stoddart RI-FI Meters Cover the Frequency Range of 14 kc to 1000 mc**

NM-20B — HF
15 kc to 25 mc. Commercial equivalent of AN/PRM-1A. Self-contained batteries. A. C. supply optional includes standard broadcast band, radio range, WWW and communications frequencies. Has BFO.

NM-30A — VHF
20 mc to 400 mc. Commercial equivalent of AN/URM-47. Frequency range includes FM and TV bands.

NM-50A — UHF
375 mc to 1000 mc. Commercial equivalent of AN/URM-17. Frequency range includes Citizens band and UHF TV band.

STODDART AIRCRAFT RADIO Co., Inc.
6644-B Santa Monica Blvd. Hollywood 38, California • Hollywood 4-9294

New Products

(*Continued from page 38A*)

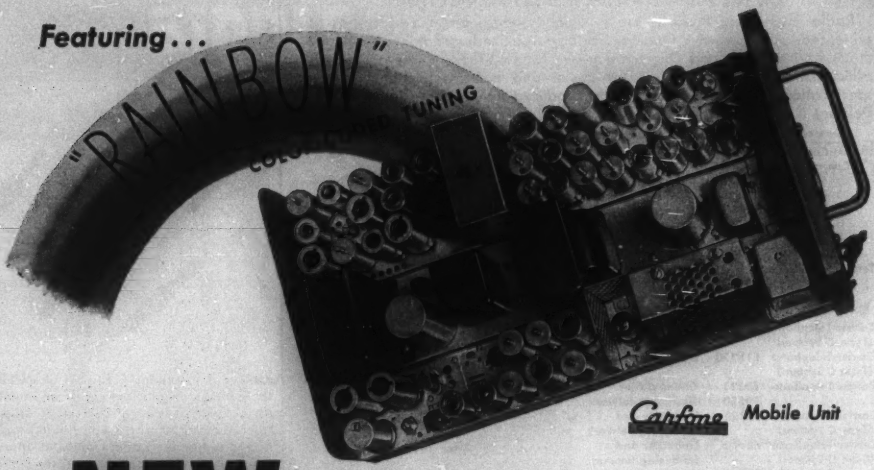
Corporation, New York, N. Y. Gains of over 100 db are obtained simultaneously with bandwidths over 12 mc at center frequencies of 30, 60, or 90 mc. Unusual design and construction provides complete shielding and absence of regeneration even with covers removed. Each model consists of a Lo-Noise Cascode amplifier followed by three flat-staggered triples. The last triple feeds an infinite impedance detector and a cathode follower output stage. A bias adjustment is incorporated in each unit to control the gain over a range of at least 40 db. Provisions are made to monitor crystal current. The Maxson i-f amplifiers are available in three models, *M1154* at 30 mc, *M1155* at 60 mc, and *M1156* at 90 mc. Data sheets are obtainable from Maxson Instruments, 47-37 Austell Place, Long Island City 1, N. Y.

Telex Boom-Type Headset. Extreme lightweight, and hearing comfort are two features of the Boom-Type headset recently developed by Telex, Inc., St. Paul, Minn. Designed for telephone operators, pilots, radio and television personnel, receptionists, and

others who require a two-way headset, the unit weighs only 3.4 ounces. It slips over the head, and sound is piped into the ears through twin tone arms, leaving the ears uncovered for greater comfort. Single cord connection keeps out of the user's way, while single or twin plugs give accurate sound reception. Varied plug-in connections are available with the headset for special applications. For additional information on the Boom-Type headset, write Department KP, Telex, Inc., Telex Park, St. Paul, Minn.

Improved Aerial Cable. Improved performance and and marked savings in the purchase, installation, and maintenance of power lines are available from Hendrix Wire and Cable Company, Boston, Mass., with a new type of

(*Continued on page 44A*)



NEW RCA 2-WAY RADIOS

The new Carfone "150" and Carfone "450" mobile communications systems are both designed to assure minimum maintenance. You can thank RCA's simplified "Rainbow" tuning for that. Adjustments are reduced to child's-play by easy-to-follow color indications and all-top tuning. And both offer the appearance advantage of dynamic shadow-box styling... plus a wealth of advanced engineering features throughout. Complete 6-12-volt convertibility, full all band coverage without change of components, sealed selectivity, compact, sturdy case.

Add up all the advanced features in these two great RCA mobile communications systems and you'll understand why superior performance is the result. And remember ... the RCA Service Company provides installation and service on a nation-wide basis. Mail coupon below for further information.

DISPATCHER 2-WAY RADIO TO DRIVER

"Get the Best"

RADIO CORPORATION of AMERICA
COMMUNICATIONS EQUIPMENT
CAMDEN, N.J.

Radio Corporation of America
Communications Equipment, Dept. X-42, Building 15-1, Camden, N. J.

Please send me more particulars about the new

☐ RCA Carfone "150" 2-Way Radio ☐ RCA Carfone "450" 2-Way Radio

Name.....

Title.....

Company.....

Address.....

City..... Zone.... State.....

WAVE FILTERS AND OSCILLATOR NETWORKS FOR FREQUENCY-DIVISION MULTIPLEX SYSTEMS

Radio Engineering Products are leading designers and manufacturers of advanced-technique wave filters and bridge-stabilized oscillator networks for the voice-frequency and carrier-frequency ranges. These filters are mostly miniaturized in hermetically-sealed cases, and meet applicable military specifications. Standard units currently produced include those listed below. Delivery is from stock.

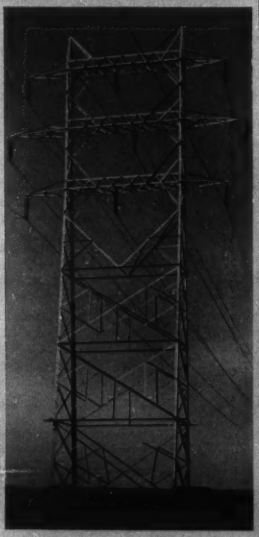
Service	Type	Function	Spacing	Range	No. of chans.
A-M Carrier-Telegraph	F2124	Send filter	170 cycles	255-4835 cycles	28
"	F2125	Receive filter	170 "	255-4835 "	28
"	F9610	Oscillator network	170 "	255-4835 "	28
"	F6131	Send filter	120 "	300-4980 "	40
"	F8261	Receive filter	120 "	300-4980 "	40
"	F9631	Oscillator network	120 "	300-4980 "	40
F-S Carrier-Telegraph, S+Dx	F11294	Send filter and oscillator network	120 "	3120, 3240, 3360 "	3
"	F11291	Receive filter and discriminator network	120 "	3120, 3240, 3360 "	3
"	F11209	Low-pass filter	—	0 to 2950 "	—
Carrier-Telephone (Type C System)	F15002	Channel filter	approx. 3 kc.	3-32 kc.	8
Carrier-Telephone (Type C System)	F15340	Oscillator network	approx. 3 kc.	3-32 kc.	8
Carrier-Telephone	F9511	Channel filter	4 kc.	4-36 kc.	8
"	F9520	Oscillator network	4 kc.	4-36 kc.	8
Carrier-Telephone (Type C System)	F2121	Line filter and balancing network	—	5-kc. crossover	—
Carrier-Telephone (Type C System)	F8910	Line filter and balancing network	—	3-kc. crossover	—
Carrier-Telephone (Type H System)	F1922	Line filter and balancing network	—	3-kc. crossover	—

We will promptly supply full information on these and other types on request.

RADIO ENGINEERING PRODUCTS
1080 UNIVERSITY STREET, MONTREAL 3, CANADA
Telephone: UNiversity 6-6887 Cable Address: Radenpro, Montreal
MANUFACTURERS OF CARRIER-TELEGRAPH, CARRIER-TELEPHONE AND BROAD-BAND RADIO SYSTEMS

FLINT

developed
designed
detailed
fabricated



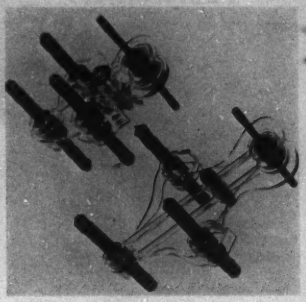
this unique Triple-Circuit Tower

The *completely integrated* service offered by Flint made this unusual tower possible. From original idea to actual erection, Flint was there. When you build *anything* with galvanized structural steel why not take advantage of this unusually complete Flint service.

FLINT STEEL
TULSA
MEMPHIS
Sold Competitively Everywhere

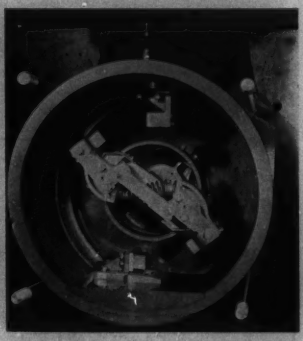
New Products

(*Continued from page 40A*)



cable and suspension. Instead of spiralling the insulated conductors tightly and binding them to the messenger cable that supports them, the new Hendrix Cable system employs acrylic plastic insulating clamps at approximately 30-foot intervals to hold the conductors closely spaced and attached to the messenger. Two sizes similar in design space the conductors 3 inches and 6 inches equilaterally, and are called Tri-*3*, and Tri-*6* Hendri-clamps. The first is used for operating voltages less than 5,000 volts, and the Tri-*6* for those more than 5,000 volts; although the large clamp may be used on the lower primary voltages at 40-foot intervals. Thus, the conductors are installed on full-voltage insulators throughout the circuit length; they require no shielding and only enough insulation for protection against voltage breakdown when unusual conditions cause them to touch another hot conductor or grounded object.

New Contactor for Tap Changing. A heavy-duty contactor which will increase the present range of typical regulating autotransformers has been developed by the General Electric Company's power transformer department, Pittsfield, Mass. Autotransformers with ±10 per cent regulation have been limited to about 150,000 kva. The



(*Continued on page 46A*)

BIDDLE *Instrument News*

BIDDLE CORONA TESTING EQUIPMENT

For Non-Destructive Evaluation of Electrical Insulation in Transformers, Cables, Capacitors and Other Electrical Components

for ionization starting voltage at 60 cycles

Models and Ratings to Suit Your Application

Ionization, corona and radio noise are synonymous in describing the phenomena which occurs when a high voltage gradient applied to voids in a dielectric causes ionization of the gas in those voids. The result is electrical disturbance and possible damage to insulation. The Biddle ionization test set offers a decided advantage in practical testing in that it makes possible the grounding of one terminal of the component under test.

The set includes all necessary connecting leads and accessory mercury oil terminal for use in testing samples of shielded cable. Model I rating ¾ KVA at 20 KV. Also available with 5 KVA intermittent rating.

Write for **Bulletin 66-EE**

JAMES G. BIDDLE CO.

- ELECTRICAL TESTING INSTRUMENTS
- SPEED MEASURING INSTRUMENTS
- LABORATORY & SCIENTIFIC EQUIPMENT

1316 ARCH STREET
PHILADELPHIA 7, PA.

Insulation Tester & Wheatstone Bridge in One Easily Portable Instrument

Measures Electrical Resistances From a Fraction of an Ohm up to 1000 Megohms

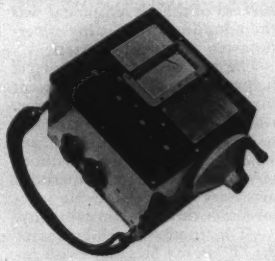
Saves Cost of Two Instruments

Saves Testing Time

Affords the facility of:

- *A Wheatstone Bridge* for measuring conductor resistance of coils, resistors and circuits.
- *A Megger® Direct Reading Ohmmeter* for measuring electrical insulation resistance (ohm and Megohm scales).
- *A Varley Loop Feature* for locating faults on wires (optional).

This Bridge-Meg weighs only 15 lbs. and is completely self contained with its own constant-voltage generator—no need to be dependent on batteries or other suitable test current.



Why burden yourself with two instruments when you can have the facilities of two for little more than the price of one in one compact, sturdy case. For complete details and prices write for **Bulletin 21-60-EE.**

Whatever your requirements in electrical resistance testing follow the lead of electrical men everywhere—*insist on Megger Instruments—with the long, trouble-free life line.*

James G. Biddle Co. B-526
1316 Arch St., Phila. 7, Pa.
Gentlemen:
Please send me material checked:
☐ 66-EE ☐ 21-60-EE

NAME
JOB FUNCTION
COMPANY
ADDRESS

SELECTED FOR IT-E 's NEW "E" FRAME CIRCUIT BREAKER

The new I-T-E "E" frame circuit breaker marks a significant advance in obtaining high ratings for small breakers. The "E" frame design now provides ratings up to 100 amperes at 250 volts a-c, in a more compact breaker than previously required. The resulting space-saving advantage means smaller over-all size of 100-ampere, 250-volt panelboards.

A contributing factor in the success of this development was the adoption of Gibsiloy silver-tungsten electrical contacts.

The use of Gibsiloy contacts helps make possible the efficient performance of the "E" frame. And, Gibson-developed contacts in the "E" frame breaker are small and economical without sacrificing any of the qualities necessary for dependable performance through constant duty.

I-T-E, in the development of the "E" frame breaker—with increased rating, compact design, and economy of operation—drew from Gibson's 23 years' experience and ability to provide the right electrical contact for their new breaker. Call on Gibson to help solve *your* contact problem.

Write for free Gibson Catalog C-520 giving much useful technical data on electrical contacts. No obligation.

CONTACT GIBSON FIRST

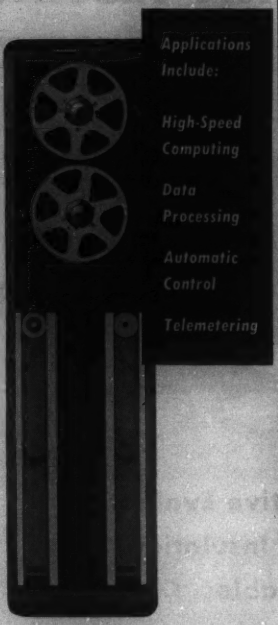
Gibsiloy
ELECTRICAL CONTACTS
Manufactured by
GIBSON ELECTRIC COMPANY

8348 Frankstown Ave., Pittsburgh 21, Pa.

DataReader

Model 546

A transport unit for high speed searching, reading and recording of data on magnetic tape.



PERFORMANCE:

RAPID START—STOP—REVERSE—from stop to full speed in 6 milliseconds.

HIGH TAPE SPEED—optional single speed of 30, 40, 50, 60 or 75 in/sec.

TWO-DIRECTION SEARCH—either direction, automatically at full speed.

REMOTE OPERATION—forward, reverse, stop, rewind and selection of reading and writing.

VACUUM COLUMN TAPE CONTROL—provides strain-free tape feed over entire length of tape.

END-OF-TAPE SENSING—stops automatically at either end of tape.

RAPID REWIND—2400 ft. of ½" or ¾" tape in 3 minutes.

FOR FURTHER INFORMATION WRITE
ElectroData Corporation
Component Sales Division
460 No. Sierra Madre Villa
Pasadena 15, Calif.

ElectroData

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CONSOLIDATED ENGINEERING CORPORATION
OF PASADENA, CALIFORNIA
ElectroData Corporation maintains a nationwide sales and service organization.

New Products

(*Continued from page 44A*)

new contactor, designated *LR81*, will extend that limit to about 400,000 kva. Rated 3,000-amperes normal continuous duty, the contactor is of the double-break, oil blast type, and is insulated for 46-kv circuits. It is capable of completing a tap change at very heavy overloads up to the full short-circuit rating of the transformer. While the first application of the new contactor was in the quadrature control of a 194,775-kva regulating transformer for the Commonwealth Edison Company of Chicago, Ill., it will be used generally in two classes of General Electric equipment: phase-shifting transformers for large capacity; and power transformers where, to save weight and losses, the usual series transformers have been eliminated.

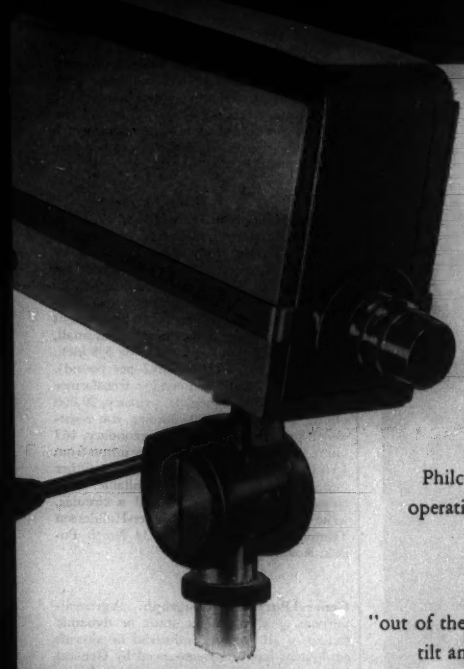
Spring Actuated Slip Sockets. Techron, Incorporated, 254 Friend Street, Boston, Mass., has announced production of the micro-pin socket, a new development that makes possible solderless connecting of diodes, transistors, and other components into a

circuit, particularly a printed circuit. Adaptable for subminiature assemblies, it has applications in computers, guided missiles, telemetering, small radio receivers, hearing aids, etc. The micro-pin socket is a spring-backed, plug-in socket made of copper alloy. Its outer shell is approximately 0.2 inch long, and 0.08 inch in diameter. It is press-fitted and dip-soldered into the circuit board, making an excellent electrical contact for leads from any component.

Machine Inserts Self-Retaining Terminals. A newly developed automatic machine makes it possible to insert almost any number of terminals into a printed circuit board in two stages within a 3-second cycle. Insertion is accomplished simultaneously in any symmetrical or nonsymmetrical pattern. Since the terminals or pins are self-retaining, they will not vibrate loose during additional assembly or other operations prior to permanent soldering. The operation is completely automatic. Terminals or pins in chain form are fed from two reels, simultaneously, through the die into the printed circuit board feeding mechanism. Full information, including Bulletin *551*, can be obtained from Malco Tool and Manufacturing Company, Department EGN, 4025 West Lake Street, Chicago, Ill.

(*Continued on page 48A*)

PHILCO *Industrial TV*

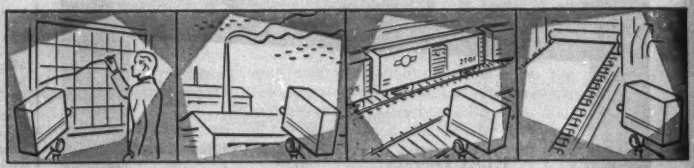


The Watchful Eye that *Never Sleeps!*

Now you can have 24-hour supervision of operations . . . perform a thousand and one tasks at a distance . . . in the next room . . . across town or many miles away. In steel, chemicals, railroads, scientific research . . . *in any industry* . . . Philco Industrial TV gives you a fast accurate picture of important operations . . .warns you of dangerous conditions . . . lets you direct progress just as though you were on the scene!

The amazingly compact Philco Industrial TV Camera fits in "out of the way" places . . . can be equipped for remote control of pan, tilt and lens adjustment. The super-sensitive camera easily picks up *all* the detail, even in dimly lighted areas and a powerful, high-definition monitor displays a crisp, clear picture in the room where *you* are. Here's complete control—*right now* saving industry thousands of dollars . . . precious hours . . . even priceless lives! Get complete data on the dependable Philco Industrial TV equipment. Write to Philco Dept. EE today.

Philco Large-Screen Professional TV Monitor and Control Units.



Instantly relays graphic information to vital points. Useful in factories, banks, retail establishments.

Warns of smoke violations. Affords constant protection of property in power plants and factories.

Keeps constant watch on cargo shipments night and day whether by rail, truck or air freight.

Scans production lines. Warns of mechanical failures. Ideal for steel, paper, auto manufacturers.

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GOVERNMENT AND INDUSTRIAL DIVISION • PHILADELPHIA 44, PENNSYLVANIA

In Canada: Philco Corporation of Canada, Limited, Don Mills, Ontario

ELECTRONS. INCORPORATED
127 SUSSEX AVENUE
NEWARK 3, N. J.
Remington Rand's Univac 120 uses Electrons' xenon, high current, temperature-free thyratron and rectifier tubes for reliable power supply.

New Products

(*Continued from page 46A*)

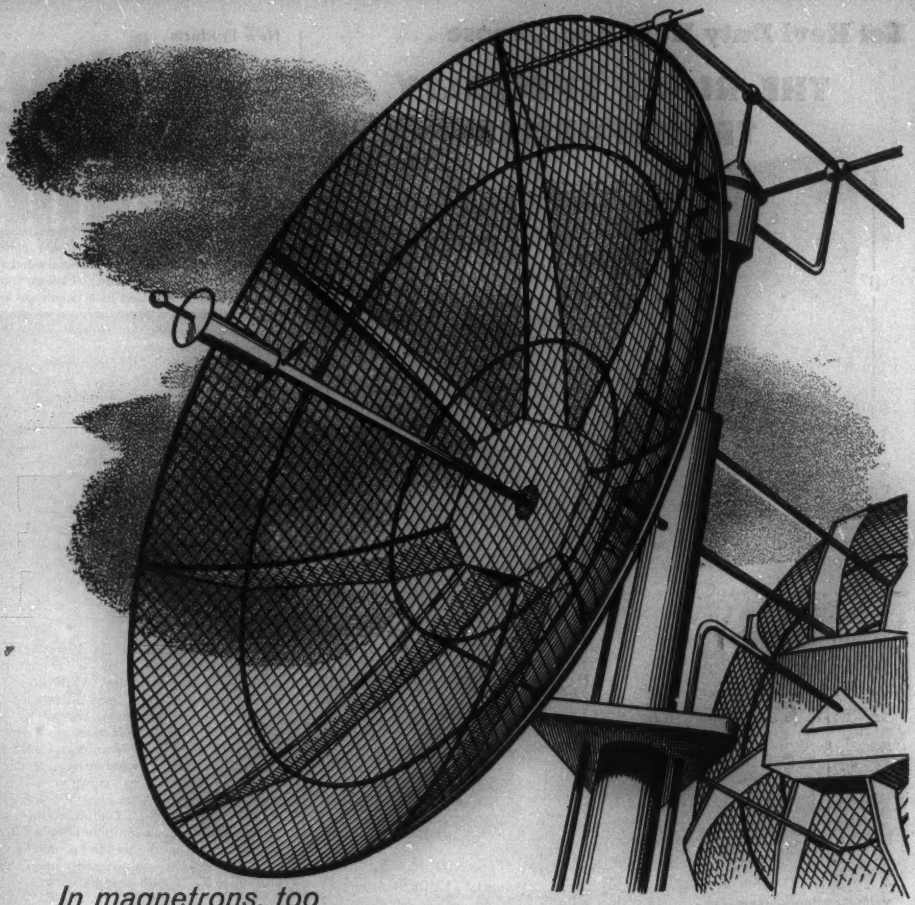
Electrical Insulation Material. A new "ceramoplastic" electrical insulation material that can withstand the effects of radiation and 1,000 F temperatures, without losing its properties, has been developed by the Mycalex Corporation of America, Clifton, N. J. The new material, called Supramica (registered trade-mark) ceramoplastic, consists of pulverized synthetic mica bonded with high-grade electrical glass. The performance of Supramica at high temperatures is due to the use of synthetic mica rather than natural mica.

Gramer-Halldorson Transformer. A Miniformer miniature transformer, reduced in size and weight, has been introduced by Gramer-Halldorson. Designed to meet the smaller space requirements of hearing-aid components, the new Miniformer has additional applications where space and weight factors are of prime importance. This small, light unit measures 1/4 by 5/16 by 3/8 inch, and weighs 0.004 pound (242 per pound). The model *100W72* interstage transformer has a match impedance of: primary, 20,000 ohms; secondary, 1,000 ohms; d-c resistance; primary, 1,030 ohms; secondary, 167 ohms. Power rating for primary inputs from 1 volt to 7 volts: 2.5 milliwatts. Other impedance matches are also available. For complete engineering data and a circular, write Department EE, Gramer-Halldorson Transformer Corporation, 2734 North Pulaski Road, Chicago, Ill.

General Purpose Oscillograph. A general-purpose oscillograph for static or dynamic testing of all types of industrial or aircraft equipment has been announced by General Electric's instrument department at Lynn, Mass. It will record up to 71 individual variables on one oscillogram when combined with suitable transducers and amplifiers for the measurement of pressure, vibration, strain, flow, etc. This makes it possible for users to record, simultaneously, the many variable factors encountered in dynamic testing of machinery. A wide choice of galvanometers, usable up to 6,000 cycles per second, provides flexibility of measurement, whether tests involve a new jet engine, an automotive suspension system, or performance testing of aircraft structures.

Micromotor. A low-cost commutator Micromotor, type *TW*, has been announced by Redmond Company, Inc., Owosso, Mich. Designed for use on various domestic appliances, as well as for automobile window lifts, seat adjustors, windshield wipers, air conditioners, marine pumps and blowers, this new motor is wound for both direct current and alternating current. It is available in sizes from 1/100 hp at 1,500 rpm to 1/4 hp at 15,000 rpm. A unique feature of the type *TW* motor is the skewing of the field laminations where straight slots are used in the armature to facilitate armature winding operations. Another major design feature is the uni-cast field. This means that

(*Continued on page 50A*)



In magnetrons, too

CRUCIBLE PERMANENT MAGNETS

provide maximum energy... minimum size

In designing magnetrons for radar systems — or any very high-frequency oscillator application — you can be sure of a *consistently higher* energy product with Crucible alnico magnets. *This means more power from a minimum size magnet!*

Crucible alnico permanent magnets are made to meet practically any size requirement from a fraction of an ounce to several hundred pounds. And they're sand cast, shell molded or investment cast to the exact size, shape, tolerance and finish you need.

Crucible has been one of the largest producers of permanent magnets since the development of alnico alloys. Its unsurpassed magnet experience is backed by over 50 years of fine steelmaking. That's why the best solution to magnet problems starts with a call to Crucible. *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

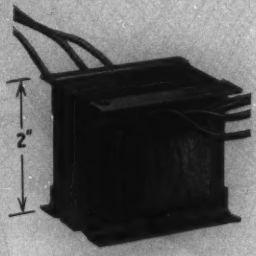
Let Hevi Duty Help You Choose

THE RIGHT SPECIALTY TRANSFORMER

This autotransformer is used for reduced-voltage starting of synchronous and induction motors. 50, 65 and 80 percent taps are normally provided. Terminals may be mounted on the coil or leads.

This is just a small sample of the broad line of specialty transformers built by Hevi Duty Electric Company. They are available in all sizes with any desired primary or secondary voltages or frequencies. All are designed to meet or exceed NEMA standards.

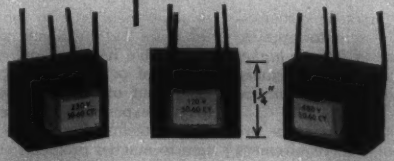
Type SICB, 150 VA, 230/460-115 volts, enclosed style with a built-in thermal circuit breaker for overload protection. This compact unit saves valuable panel space.



Type SIO, 10 VA, primary 110/220 volts

CONTROL WINDING	FILAMENT WINDING
Secondary 230 volts, .032 amps, 7.4 VA	Secondary 6.3 volts, .3 amps, 1.9 VA

Low-voltage pilot light transformers up to 600 V primary.



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HEVI DUTY ELECTRIC COMPANY

MILWAUKEE 1, WISCONSIN

Heat Treating Furnaces . . . electric exclusively

Dry Type Transformers *Constant Current Regulators*

New Products

(*Continued from page 48A*)

the laminations are stacked and die cast together under pressure to eliminate shifting and vibration during motor operation. Engineering data and specifications are available on request.

Precision Recorder. With the Minifon *P55*, recordings can be made indoors or out, while driving or flying, and under conditions where using the conventional-sized recorder would be impossible. Though small enough to be concealed in a man's pocket, the recorder will make speech recordings up to 5 hours; music recordings up to 2½ hours—all on a single reel of wire. With its standard crystal microphone, recordings can be made of sound as far away from the microphone as 20 feet. Push-button control provides instantaneous action for recording, stopping, rewinding, playing back, erasing by re-recording, and rewinding. With its dictation footage clock, the Minofon is also suited for dictation purposes. Recordings can be played back through stetoset earphones, speaker-microphone, through any radio, television set, or external amplifier. For further information, contact Geiss-America, Chicago 45, Ill., exclusive United States of America representatives of the Minofon *P55*.

New Aluminum Alloy for Electrical Industry. Development of a new high-strength aluminum alloy, designated as Revere alloy *6263*, has been announced by Revere Copper and Brass, Inc. This development is the culmination of Revere's joint research with the Aluminum Company of Canada. The magnesium silicide alloy, applicable for use as lightweight high-strength conductors, has been approved for busway applications. The company will recommend its new aluminum alloy *6263*, or copper, or EC grade aluminum, depending upon the particular requirements and whichever offers the best advantages to the user.

Magnetic Tape Recorders. Designed for the acquisition of flight test data, a new series of airborne magnetic tape recorders has been introduced by the Instrumentation Division of the Ampex Corporation. Series *800* equipment, the lightweight, shock-resistant recorders are available in versions ranging from units designed to record two channels of information on 1/4-inch tape, to models intended for recording 28 tracks on 2-inch tape. Model *807* records seven information tracks on tape 1/2-inch wide. It consists of five cable-connected units which can be mounted in any configuration desired, limited only by the length of the cables. Complete details, including environmental operating specifications, are available from the Instrumentation Division, Ampex Corporation, 934 Charter Street, Redwood City, Calif.

Guided Missile Timer. A small timer by Raymond Engineering Laboratory of Middle-

(*Continued on page 54A*)

to stay Dunkirk power station

INSTALLING two 7-conductor "Rolene" insulated cables at the rear of the main control board. Despite varying ambient temperatures throughout the station—in some places as high as 130 deg. F.—BAKELITE Polyethylene stays flexible, will not dry out and crack.

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AC-DC CONVERTER

and an NLS Digital Voltmeter

--relay or stepping-switch type!

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30 to 200,000 cycles per second
0.1 percent accuracy
4-digit luminous display
automatic recording optional

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INDUSTRIAL RELIABILITY
VOLUME-PRODUCTION PRICES

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for that short grid lead

use the Sangamo

Tote-m-pole

First used in Navy electronic gear, Tote-m-poles are invaluable for "bug-resistant" wiring of models and production units. Advantages: Short leads; high component density; improved ventilation.

Tote-m-pole supporting "T" network of 5 resistors and 4 capacitors.

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New Products

(*Continued from page 50A*)

town, Conn., is specifically suited for airborne equipment or missiles The unit contains a spring-wound timer and a single-pole double-throw switch which is thrown at the end of the set time. The unit is available with three different types of actuators: pull wire, dimple (explosive) motor, or g weight actuators, which start the timing cycle. Maximum time delays vary from 1 second to 6 minutes in the various models The switch is rated at 5 amperes, 250 volts, noninductive. The unit will operate at 40 g, −60 F to +200 F with an accuracy of ±10 per cent. It is $1^1/_2$ inches in diameter and $1^1/_{16}$ inches deep behind the panel.

TRADE LITERATURE

Radar Transformer Bulletin. Oil-filled transformers and inductors for radar, and other electronic applications are described in a new bulletin, *GEA-5963*, available at any General Electric Company apparatus office or from the company's headquarters, 1 River Road, Schenectady 5, New York. The bulletin cites the radar transformer model shop, where prototype units can be designed and built in a hurry.

Vulcanized Fibre and Laminated Plastic. "Engineering Materials For Modern Industry," and "Mechanize Your Wiring with Copper-Clad Phenolite" are the titles of new 2-color bulletins published by National Vulcanized Fibre Company, Wilmington, Del., covering the properties, grades, and uses of National vulcanized fibre and Phenolite laminated plastic. Case studies illustrated by photographs match physical properties to typical uses for both of these materials. Tables list the general properties of the several grades of National vulcanized fibre, and the 40 grades of Phenolite laminated plastic. Copies of these bulletins are available without charge from National Vulcanized Fibre Company, 1055 Beech Street, Wilmington 99, Del., or National Fibre Company of Canada, Ltd., 107 Atlantic Avenue, Toronto, Ontario, Canada.

Radiation Measuring Equipment. A 48-page, catalogue released by the Nuclear Instrument and Chemical Corporation, 229 West Erie Street, Chicago, Ill., describes radiation measuring equipment for medical, industrial, and research applications. Included are photographs and descriptions of individual instruments as well as suggested groupings of units for specific applications. Copies will be sent on request.

Measuring Instrument. The proximity meter, a precision electronic instrument that measures without touching the speci-

(*Continued on page 57A*)

Trade Literature

(*Continued from page 54A*)

men, is described in a 28-page booklet offered by the manufacturer, Fielden Instrument Division of Robertshaw-Fulton Controls Company. The instrument can detect a change in temperature of one thousandth of one degree centigrade, or variations as minute as one millionth of an inch. Copies of the proximity meter technical and application manual may be obtained upon request from Fielden Instrument Division, Robertshaw-Fulton Controls Company, 2920 North Fourth Street, Philadelphia, Pa.

Switches Catalogue. A 28-page catalogue, number *83*, covering a complete line of industrial enclosed switches has been published by Micro Switch, of Freeport, Ill., a Division of Minneapolis-Honeywell Regulator Company. Published as an aid to the plant engineer and maintenance man, as well as the designer of original equipment, catalogue *83* describes the wide variety of enclosed switches which are designed for use on either alternating-current or direct-current industrial applications.

Lighting Catalogue. A complete commercial lighting catalogue has been published by the Cold Cathode Lighting Corp. The catalogue, is designed to give architects, engineers, and contractors basic information in the use of cold cathode equipment. For copies of this catalogue, write Engineering Department, Cold Cathode Lighting Corporation, 42-40 27th Street, Long Island City, N. Y.

Kodak Revises Pamphlet on Using Slide Sequences. Suggestions for the preparation and effective use of color slide sequences in business and education presentations are covered in an Eastman Kodak pamphlet. The revised leaflet stresses the advantages of sequence of a 2- by 2-inch slides. Suggestions are given for planning the slide sequence to assure adequate quality for the intended purpose. Amateur production for use within a business organization or school or in connection with a hobby or profession is described. Additional space is given to such subjects as photographing small objects, diagrams and text slides, duplicates, and preparing the commentary, presenting slide sequence, dissolve projections, and special projection equipment. The pamphlet concludes with a listing of free Kodak literature useful as references. Copies of the 8-page "Notes on Color Slide Sequences as Aids in Business and Education," are available without charge from the Sales Service Division, Eastman Kodak Company, Rochester 4, N. Y.

Mueller Clip Catalogue. A revised catalogue, number *180*, of electrical and electronic clips and insulators has been issued by Mueller Electric Company of 1557G East 31st Street, Cleveland, Ohio. The illustrated catalogue includes new miniaturized and special insulated clips. Write to the Mueller Electric Company for a free catalogue.

Further Proof of

Getting to the bottom of things

. . . is most clearly demonstrated by what we are doing every hour of every day — year in and year out — to make a finer fixed CAPACITOR.

One of the many things you as users are interested in is the "LIFE OF THE CAPACITOR" under a multitude of operating conditions. We in the FAST organization have spared no expense to give you honest-to-goodness answers on this important factor in providing quality capacitors.

What follows is a summary of what we are doing to give you just that . . .

I: RESEARCH and DEVELOPMENT TESTS

AC and DC tests at various temperatures and voltages.

1—Investigation of Impregnants: (a) New impregnants AC/DC—synthetic and natural oils, resins and waxes. (b) Studies of impurities and additives.

2—Investigation of electrode separators and electrode materials: (a) Kraft papers—standard, low PF varieties, sundry densities and deionized. (b) Films — regenerated cellulose, polystyrene, teflon, "Mylar"*, Etc. (c) Electrodes — Dry annealed and neutral aluminum; and tin.

3—Number of groups tested: AC; over 800 involving more than 8000 units. DC; over 3700 involving more than 78,000 units.

4—Duration of tests: AC; many have been continuously under test for over 6 years. DC; many have been continuously under test for over 10 years.

5—Voltage range of tests: AC; 70 to 2400 volts at 60 and 400 cycles. DC; 140 to 44,000 volts.

6—Temperature range of tests: AC; Room to 130°C. DC;—55°C to +150°C.

II: PRODUCTION TESTS

A. Alternating Current

1—Heat runs on production lots — ultimate surface temperature rise.

2—Ultimate life hours of current production (periodic tests run).

B. Direct Current

1—Civilian Production: (a) ultimate life hours of capacitors taken from current production. (These test runs comprise over 1800 groups involving more than 21,000 units).

(b) Ultimate life hours of capacitors after being stored in cartons from 1 to 24 months under normal variations in humidity and temperature. (These test runs comprise over 324 groups involving more than 3240 units).

2—Military Production: (a) Test to applicable specifications (Mil-C-25; Mil-C-91; U. S. Army 71-1667; Etc).

(b) These test runs comprise over 4200 groups involving more than 24,500 capacitors.

Please note Carefully: at least 75% of the 134,740 capacitors included in the above tests were tested to ultimate destruction at voltages ranging from rated to 4 times rated and at operating temperatures from lower than, to maximum rated or in excess of. Many outside this group have not failed to date. Importantly too, this is a continuous policy of the company in sustaining its testing program throughout every day—year after year.

So, with pardonable pride, may we suggest "QUALITY CAPACITORS" is more than a catch-phrase as applied to FAST CAPACITORS?

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**Du Pont trade-mark for Polyester Film.*

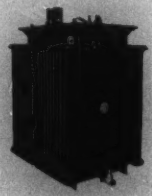
engineers of leading industries are specifying

Courtesy Newark Evening News

South front of beautiful, ultra-modern office section of new Ford plant at Mahwah, N. J.

Marcus TRANSFORMERS

Marcus Transformers installed for lighting distribution in new Ford plants near San Jose, California, Louisville, Kentucky, and Mahwah, New Jersey as part of the Ford Motor Company's huge coast-to-coast multimillion dollar expansion program.



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PURE COPPER	RE-USABLE
100% CONDUCTIVITY	ALL WIRE SIZES
COOLER OPERATION	ECONOMICAL

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American Standard for POOL CATHODE MERCURY-ARC POWER CONVERTERS

Sponsored and published by AIEE, this standard (C34.1–1949), applies to all types of mercury-arc power converters, employing rectifying devices with mercury pool cathodes and used for power conversion purposes, including mercury-arc power rectifiers and inverters, electronic frequency changers and converters used with electronic motors when these equipments employ mercury-arc rectifying devices with pool cathodes. Price: $1.20; 50 per cent discount to members. Address:

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